

THE

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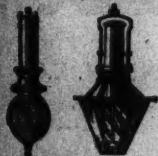


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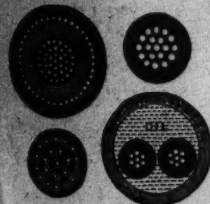
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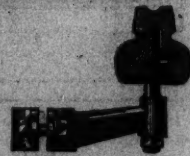
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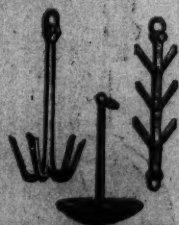


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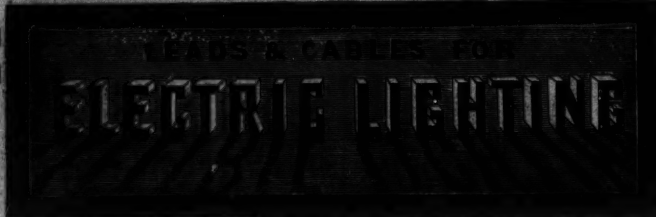
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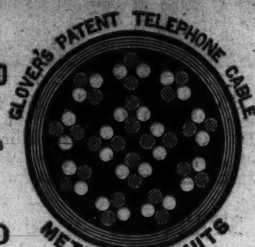
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THE TELEGRAPHIC JOURNAL AND ELECTRICAL REVIEW.

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THE VALUES OF γ AND J .

WE first noticed Mr. Donaldson's attack on the work of Sir Wm. Thomson on the ground of its affording an effective illustration of the evil of careless reading. We continue our animadversions, because we think his letters are also an astonishing exhibition of how reckless even wranglers can be when their strife is "for triumph more than truth." We entered into this controversy thinking to earn Mr. Donaldson's gratitude, having first been won over to him in friendly feeling by his statement in the *Engineer* for July 17th, p. 54:—"In my early days, when I acquired the little scientific training I possess, scientific men pursued their investigations with the object of finding out the truth, and were therefore grateful to, not offended with, those who point out errors in the steps of their investigations."

Fact 1.—We accordingly pointed out to him that it must have been from careless reading that he had become possessed of the idea that equation (32) is one having reference to the value of J , in the sense of determining that value. He replied, July 31st, that if we had been more in touch with the engineering professional world, we would have known that the result of equation (32) has been regarded as a strong corroboration of the correctness of Joule's value of J . We asked for even one name, other than his own, committed to this opinion, and he is constrained to admit now that, to the best of his knowledge, he is the first and only author of the opinion as a printed statement, but, he says, "that it ever should have been so considered is unquestionably very absurd." He wishes, nevertheless, that our readers should still believe that in "the engineering professional world" with which he is "in touch," there is at least another man who has shared with him this absurd opinion. Well, this looks very much like as if he were now admitting that we had pointed out an error in the steps of his investigations, since we both say that it is absurd that anyone should ever have considered that equation to have any reference to the value of J . But, where are there any signs of that gratitude to which he said we would be entitled? And where is his retraction of the

letter to the *Engineer* of July 3rd, based upon the opinion that equation (32) had "reference to the value of J ?" If it is "unquestionably very absurd that it ever should have been so considered," it must be still more absurd that anyone should have written a series of letters based upon that absurdity attacking an eminent author. And where is the apology of Mr. Donaldson for having stated in these foundationless letters that "In the article on 'Heat' in the 'Encyclopædia Britannica,' Sir William Thomson states that the correctness of Joule's value of J has been confirmed by the results of experiments carried out jointly by himself and Joule?" whilst, in his present letter he denies this, saying, "I have never seen it stated in writing that the result of equation (32) is a strong corroboration of the correctness of Joule's value of J ." He ought surely to apologise on the plea, as we suggested, of careless reading, or else quote the statement of Sir William Thomson upon which he started. We cannot find any such statement in the article referred to; and, as Mr. Donaldson has publicly charged Sir Wm. Thomson with having made it, surely we were entitled to call upon him to give "chapter and verse" for it.

Fact 2.—We gave the statement in Maxwell's words, which stand on p. 27 of his "Theory of Heat," "It is found that actual gases fulfil with greater or less degrees of accuracy certain numerical laws, which are commonly referred to as the 'Gaseous Laws.'" This is Maxwell's statement of Maxwell's opinion of these laws. Here, now, is Mr. Donaldson's statement of Maxwell's opinion of them, in the letter on p. 236, "Maxwell does not, himself, regard the law of Boyle and Marriotte as approximate only; nor is it so." The inference from this is, that in Mr. Donaldson's opinion, Maxwell was not "himself" when he wrote the chapter "On the Gaseous State," and that, somehow, to Mr. William Donaldson has been confided the duty to give posthumous expression to what were Maxwell's private convictions in regard to these laws. And thereupon he gives us again the formula for the temperature of melting ice by the gaseous thermometer, about which there is no question between us. A correspondent, whose letter we think unnecessary to be printed in full, says, "The way in which he insists upon

Boyle and Marriotte's law as though it had been arranged in heaven with those gentlemen, is highly entertaining." Mr. Donaldson says "The results, therefore, of Regnault's experiments simply confirm the truth of Boyle and Marriotte." We say that Regnault's experiments demonstrate that the law does not hold good where strict accuracy is regarded, and the departures from it are always the same for the same gases and pressures. These are the exceptions which really make the law, when they can be definitely expressed as has been done by Thomson and Joule. The confirmation of the Joule-and-Thomson result by Amagat's colossal experiments, is very remarkable. Amagat, however, carries the questioning of Nature far beyond the limits of Joule-and-Thomson's experiments—up to over 300 atmospheres. We quote now from a note written some years ago, translating from *Annales de Chimie*, 1880, vol. xix., p. 385. "From the whole of the results we may conclude with the greatest probability that when a gas, after having presented, or not, a minimum of the product, $p v$, compresses in such a way that this product augments with pressure, it finds itself placed under the conditions in which, according to Mr. Andrews, it can pass by pressure alone and without liquefaction, properly called, through all the intermediary between the gaseous state and the liquid state; the augmentation of the product, $p v$, should indicate then, in a word, that the gas is at a temperature superior to that of its critical point.

"Up to the present hydrogen has not shown any minimum of $p v$, but that may be because it has not been studied under sufficiently low pressures; however, it is probable that this minimum does not exist. If we go back, in fact, to that which I have stated above, relative to the variations of the products, $p v$, and if we consider that hydrogen is according to all appearance the most perfect gas, it will appear very probable that at some temperatures more or less elevated, we should see for each gas the negative ordinate diminishing, the convexity of the curve dying out gradually, and at a temperature sufficiently elevated, the entire curve lying above the axis of abscissæ, as is the case for hydrogen at ordinary temperature."

In the diagram referred to the negative ordinate denotes diminution of $p v$, and the positive ordinate denotes increase of $p v$. At ordinary temperature, starting from pressure, 24 metres of mercury, nitrogen, carbonic oxide, air, and oxygen all diminish $p v$ with increase of pressure, the curves for these gases declare each a minimum $p v$, that for oxygen occurring at about the pressure of 125 metres of mercury. The curve rises after that and cuts the axis of abscissæ at pressure 230 metres of mercury. The curve for hydrogen is a straight line, and its $p v$, as far as drawn, is about proportional to $1216 + m$, where m is the pressure in metres of mercury. We take the 1216 from a hand sketch of the diagram which we made some years ago, and the 16 may therefore be 12 or 20.

We return now to Mr. Donaldson's more than sharp remark, "If Mons. Amagat's experimental results show that a fall of pressure of three atmospheres is only accompanied by a fall of $\frac{1}{10}$ th of a degree of temperature, they are unquestionably utterly unreliable." He still pretends to have read the article he has been discussing, but this remark proves that he has not yet even a glimmering of what is meant by Sir William Thomson in this statement:—"For the case of hydrogen the heating effect observed, amounted, per

100 inches of mercury, to 100 of a degree Centigrade at temperatures of 4° or 5° Centigrade." We stated that M. Amagat adopted the direct method, and Mr. Donaldson, by confounding the two sets of experiments shows that he has not yet wakened up to the sense of what Joule-and-Thomson and Amagat were severally trying to arrive at.

Fact 3. It is again a more than sharp expedient he resorts to to disguise the nature of this fact. He pretends that the question at issue here was whether the value of the factor,

π for air differs from that of hydrogen by one-half per cent., and by this wriggle he gets away from the duty incumbent upon him to thank us for what we explained to him under this head. We think he sees this clearly now, and we will therefore pass on to:

Fact 4. Here we wrote "This is a ——" He first attacked Sir William Thomson on the meaning of $\pi \frac{\delta t}{\delta p}$ saying, "I have met with some amazing statements, but none so amazing as the statement that $\pi \frac{\delta t}{\delta p}$ is equal to a constant negative number, &c." We pointed out to him that careless reading had led him to interpret δt and δp as if they were $d t$ and $d p$, whereas in the article they had a different signification. Notwithstanding the printed evidence of what he did write, he deliberately put in writing in his reply that he made that remark regarding $\pi \frac{d t}{d p}$. Now there is not in the whole article referred to a single instance of π and $d p$ occurring in the same equation, and $d t$ and δt are defined to have quite different meanings, $d t$ being always infinitesimal, while the δt of the experiments is a finite quantity; and δt is positive for cooling, while $d t$ is negative for cooling. Now upon this positive-or-negative was built Mr. Donaldson's original attack, and he actually wrote on page 152 that he made the remark about $\pi \frac{d t}{d p}$, concerning which his objection would have been well founded, if only he could have discovered that the expression had ever been used by anyone but himself. In all his subsequent illustrations he pretends to justify his attack on Sir William Thomson regarding $\pi \frac{\delta t}{\delta p}$ by writing

platitudes about $\frac{d t}{d p}$ about which he says his original attack was made. It is as if some one had written describing a queen as a mother, and another had rushed into print proclaiming his amazement,—"I have met with some amazing statements, but none so amazing as the statement that a queen had been a mother," then some one explains to him that queens may be mothers but they cannot be fathers, when the veracious critic replies, saying, "I expressed my amazement that any one should ever have written that a king could be a mother, and I will prove it to you now by all the genealogies known in history." It will be understood, therefore, by our readers that by the "This is a —," we meant the dash to denote the little word which alone can properly describe this kind of obliquity.

Fact 5.—Mr. Donaldson says, "The writer has beaten the record by his statement that E and v_0 are mutually interdependent variables. He knows they are not, &c." The expression, "mutually interdependent variables," was not made use of by us, the language is Mr. Donaldson's. As to the fact that E and v_0 are variables and interdependent, he has only to

refer to the article he has attacked, "Heat," page 563, second column, nine lines from foot of page. There he will find that ϵ varies with the initial pressure, and, therefore, with p_0 . The following is the order in which ϵ is in that column stated to vary with the pressure at t_0 .

E.	Pressure in c.m.			
·36632	...	...	...	44 c.m.
·3665	...	...	...	76 "
·3667	...	...	...	149 "

Fact 6.—Mr. Donaldson says that "the truth of the adiabatic relation

$$\frac{t}{t_0} = \left(\frac{p}{p_0} \right)^{\frac{\gamma-1}{\gamma}}$$

does not depend on the principle of the convertibility of heat and work." We will suppose that he means that heat and work are "mutually convertible," and as we have a "mutually" of his in stock, we have made the alteration without difficulty. Now as to the fact, how is the proof to be made? If by reasoning, then certainly it must involve the principle of a mechanical equivalence of heat. If the proof is to be an experimental verification of the relation stated, there can be no principle involved except that of not perverting the truth. As to his conclusion that "the work done during expansion depends solely on the amount of expansion, and not on the way in which the expansion is effected," we quote again from the correspondent already referred to:—"The statement that 'under no possible condition can a gas expand without doing work,' is a very unfortunate one for him, because it will open the eyes of many readers of the correspondence to the fact of his unreliableness. Those who are unable to follow the argument about the formula, will, nevertheless, appreciate at once the error committed here." We have now finished with Mr. Donaldson.

EFFECTS OF HIGH TEMPERATURES ON VULCANISED INDIA-RUBBER.

THE New York *Electrical Engineer* of August 12th, publishes an interesting article by Mr. Wm. Maver, Junr., on the effects of high temperatures upon the insulation resistance and inductive capacity of vulcanised India-rubber, in which are given the results of some tests made by him on three lengths of cable at temperatures varying between 100° and 212° Fahr.

Mr. Maver says that in some of the streets in New York abnormally high temperature exists underground, caused by defective pipes of the New York Steam Company, and that in the neighbourhood of these pipes the temperature in the electrical subways is at times as high as 200° Fahr. He further states that, although it was known that the insulation resistance of certain forms of fibrous lead-covered cables fell very rapidly above 125° or 150° Fahr., no data existed showing the effect of high temperatures upon the insulation resistance of India-rubber compounds; and that it was to supply this want that the tests mentioned above were undertaken.

Three lengths of core, each 100 feet long, were cut from the same piece, and covered externally in different ways, one length being braided and lead covered, another lead covered

without first being braided, and the third neither braided nor lead covered. The core in each case consisted of a conductor .097 inch in diameter, insulated with vulcanised India-rubber to .350 inch diameter, to give an insulation resistance of 1,500 megohms per mile at 70° Fahr. The three cables were immersed in a tank of water, the temperature of which was gradually raised to the boiling point, and measurements were made at various times which gave, taking the average of the three lengths, an insulation resistance per mile of about 200 megohms at 100°, 130 megohms at 150°, and 10·5 megohms at 212° Fahr. The inductive capacity, which is not stated in units, showed a marked increase, the values being in the proportion of 1, 1·3, and 2·4 at 100°, 150°, and 212° Fahr., respectively.

In electric light and power distribution, where rubber cables are most frequently employed, it is the variation of the insulation resistance which is more especially interesting; and if we compare the figures given by Mr. Maver with those calculated from tests on Hooper's core (these tests furnishing the only published data on this subject), we find that there is a very considerable disagreement. This may be caused partly by the figures for Hooper's core not being applicable to such high temperatures as the boiling point of water; but it is, we think, also in great measure due to the method of making the tests now under consideration. In the first place, the change of resistance from 1,500 megohms to 200 megohms per mile for a rise of temperature from 70° to 100° is enormous, as with good India-rubber core the insulation resistance should not fall for 30° rise of temperature to a lower figure than, say, 40 or 50 per cent. of its original value. We understand, however, from the article that the resistance at 70° was obtained from preliminary tests, and it is probable, therefore, that the great difference between the resistances at the two temperatures may be accounted for by the fact that the measurement at 70° was made on a greater length of cable, and that the very low resistance of 100° is due to leakage at the ends of the cable, which in such a short length as 100 feet would be a very appreciable factor.

If then we only consider the tests made on the 100-foot lengths, we find that a rise of temperature from 100° to 150° reduces the resistance to about 65 per cent. of its original value; whereas a similar rise of 50° would, according to the figures quoted in Clark and Sabine, reduce the resistance of Hooper's core to about 28 per cent. On the other hand, according to Mr. Maver, the resistance at 212° is only about 8 per cent. of that at 150°; whereas the figures for Hooper's core would reduce the resistance to about 20 per cent. for a rise of temperature of 62°. As we have already pointed out, the more rapid fall between 150° and 212° may be occasioned by the inapplicability of the figures quoted to such high temperatures; or again, it may be due to the core tested by Mr. Maver being of an inferior quality of rubber. It is, of course, well known that the effect of temperature changes on the resistance of rubber compounds varies very much with different qualities, the percentage decrease of resistance for any given rise of temperature being greater with inferior than with good qualities of rubber; but it has been generally assumed that the variation is of a similar character, and not such an one as we find here, where the decrease of resistance is abnormally small for the first 50° rise of temperature, and abnormally large for the further 62° rise.

The explanation of this may, we believe, be found in the short time that the cable was subjected to the test temperature, as we understand that the tests only extended over a period of six hours, and that the final tests were made after the cables had been subjected to the boiling temperature for over an hour, thus leaving something less than five hours for the gradual raising of the temperature from 100° to 212° . This is, we think, much too short a time, as the mean temperature of the dielectric always lags behind the temperature of the water, when this latter is changing; and it would, therefore, be interesting to know whether the rate at which the resistance would fall would be materially altered, if the tests were made in each case after the cable had been kept for a much longer time in water, maintained as constant as possible at the test temperature.

Although in England we are not troubled by the presence of underground steam supply pipes, either defective or otherwise, we yet are obliged occasionally to fix electric light wires in positions where they are subjected to high temperatures, as for example in the stoke-holes of some ships; and the question of the effect of such temperatures on the insulation has therefore a certain practical importance, as well as being of interest generally as a point upon which up to the present very little information has been published. We hope, therefore, that the example of Mr. Maver will be followed by others, so that data may be collected showing the effect of these temperatures on the various dielectrics now in general use.

THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

THE Cardiff meeting has just concluded, and by the time this is in the hands of our readers the members will have dispersed to their various homes. We can scarcely say what is the real impression caused by this year's meeting, but our own is not a favourable one. We do not wish to say anything uncomplimentary about the British Association, and with a portion of its functions we are not concerned, neither have we anything to say about the evening lectures; but we cannot refrain from drawing attention to the paucity of ideas and the meagre nature of the papers in general which have been presented to the Sections A and G. Of course we are quite aware that the absence of such men as Sir Wm. Thomson, Mr. Shaw, Lord Rayleigh, Prof. Ewing, Mr. Glazebrook, and Prof. Perry must be severely felt in the sections which deal with electrical science, but even this does not satisfactorily account for a barrenness which we do not remember to have been equalled in former meetings.

It would seem as though we are being slowly driven to accept the view, so often expressed of late, that the days of the British Association are numbered, at any rate so far as the advancement of science is concerned. As a sort of semi-scientific picnic it may drag along yet for some years, but for the furthering of useful objects its power is gone. It is not in a carping spirit that we give expression to these sentiments, nor are we anxious to whip a dead horse, for we are strongly of opinion that it is a simple combination of circumstances, which is gradually leading to a dissolution. In years gone by the Association accomplished genuine and

good work, and it must be with feelings of sadness that old members see the gradual decline of its influence of work, and a stronger desire on the part of the visitors to clutch at the cheap excursions and the teas at which no fees are exacted. The B.A. at this stage might almost be likened to an old society beauty whose day is long since over, endeavouring to recover her lost youth and potency by indulging in a series of reckless and frivolous gaieties. Glancing at the reasons which might be advanced as a probable cause of this decline, it must be granted that the conditions in which the Association exists are now very different to those which held some years ago. Such has been the advance of electrical work that very few practical men are now met at the meeting, and even these in some cases attend with the avowed and laudable object of advertising their particular branch of business. Busy men cannot afford to make the B.A. week their holiday, and if they have anything of importance to communicate, they either seek their own societies, whose meetings are more convenient, or they adopt the now very usual course of using the columns of the technical papers. At the same time it must also be borne in mind that the men who could tell us the most interesting things have not even time to write, and thus it seems to us that papers of real practical utility must become scarcer and scarcer at B.A. meetings.

A word now as to the electrical work done in the two sections. In all the papers read in Section A, there are not above one or two of any importance. A good deal of time was wasted on others which had nothing to repay the trouble of listening. Even a joint discussion with Section G, on "Electrical Units," failed to result in anything save a few well-considered suggestions from Prof. Stoney and Prof. Stroud, but the outcome is nil. There was not the absolute sterility in Section G which characterised A, but here there seemed a good deal of mismanagement on the part of somebody. Eight papers were down for reading on Monday, but a too great anxiety was exhibited to get these into as little time as possible, with consequent scant justice to the authors, and the total omission of three out of the eight. Nor can we congratulate Sir James Douglass on his want of tact in applying the closure both to authors and debaters. Some speakers were promptly asked to curtail their remarks, while others were allowed to wander on at their own sweet wills. More time ought to have been given to the electrical portion of the section, as in former years, and the shabby treatment meted out will have its due results. Altogether then, the British Association meeting of this year was a complete failure as regards electrical matters. Next year the meeting will be held in the ever popular town of Edinburgh, and this fact may bring together more scientists of the first rank, which may result in a little re-infusion of vigour into things electrical, after which we may again expect inanity.

THE DISINFECTION OF SHIPS BY AN ELECTROLYTIC METHOD.

A SHIP, as everyone knows, in spite of the purity of the ocean air, may frequently be a centre of propagation for all kinds of contagious diseases, for she takes in cargo, perhaps, at many ports, goods that have passed through all sorts of

hands, animals, perhaps, and passengers whose antecedents as to health, or the healthiness of the locality from which they come, are not enquired into. Then, again, there are sources of disease within the ship itself in the form of decaying organic matter, putrid bilge water, badly-ventilated cabins, &c., which all tend to make the air below decks objectionable, especially when the ship is passing through the tropics.

In the old days, when ships were small, the cargo used to be cleared out, and the vessel was well smoked. Now-a-days the practice is to use chemicals of an antiseptic or germ-destroying nature. But the use of disinfectants is almost powerless to prevent the danger from bad bilge water, and the problem had almost been given up, until recently Mons. Hermite came forward with a plan which depends upon the employment of electrolysis.

A battery of electrolysing apparatus is arranged between two vats placed at different levels; the lower one is kept full of sea water. A pump draws water from the lower to the upper vat, whence it descends into the electrolysing apparatus by means of a special pipe. The pump works continually, and maintains a constant circulation between the electrolysing apparatus and the two vats.

The next feature is a system of pipes which conveys the electrolysed water into all parts of the ship. These pipes are supplied with taps, or, it may be, constant jets which allow the liquid to play into the urinals, water closets, &c.; also into the basins of the lavatory. In short, wherever disinfection is needed, these pipes may be placed so that the disinfectant is laid on just like gas, water or electricity might be.

But this arrangement does not effect the disinfection of the hold. In order to render the bilge water harmless, a small pump is constantly at work bringing up the water from the hold into a special electrolysing apparatus and returning it again, thus maintaining a constant circulation. The results are stated to be encouraging in the highest degree. A full account of this process recently appeared in the *Revue de la Marine Marchande*.

The Lauffen-Frankfort
Electric Transmission
of Power.

A REUTER'S telegram in last Saturday's daily papers announced the successful starting of this gigantic undertaking. It says:—"The experiment passed off without a hitch, and the apparatus works perfectly." Next we read:—"The transmitters used are those of Lahmeyer, whereby both constant and intermittent currents are conveyed." Up till now we had understood that the whole plant was the joint production of the Allgemeine Elektrizitäts Gesellschaft of Berlin and the Oerlikon Works, and that the multiphase system described in our issue of May 29th is being used, and so far we have not received any information to the contrary from our correspondents at Frankfort and Berlin. We have printed the word "transmitters" in italics, in order to show that Messrs. Reuter's informer was misinformed in every point, save that perhaps which relates to the actual fact of setting the machinery in operation. The other part of the telegram is astonishing, and it must have been intended for a joke; for it seems dreadful to introduce "death's heads" into the matter. It might, in the case of people possessed of strong imagination, give the idea of ghosts—perhaps ghosts of the victims of the 25,000-volt-potential guarding the posts and perambulating all along the line. If these heads and posts are painted with luminous paint, which

would seem an almost necessary condition, then the aspect at night must be weird indeed. The telegram in its entirety may be read in our "Notes" columns, together with a later one which seems to be based on better authority.

Magnetic Matter
in Meteorites.

SOME specimens of meteoric iron have recently been placed under examination by J. M. Davison, of the Rochester Academy of Sciences, U.S.A. They were all found to contain kamacite, taenite and plessite. Both the kamacite and the taenite were magnetic, and exhibited a weak polarity which was more marked in the latter. Pieces of taenite floated directly upon water, and of kamacite buoyed on a cork, arranged themselves in the magnetic meridian; the taenite promptly, the kamacite after being left for some time protected from air currents under a bell-jar. The meteorite as a mass also showed polarity. Fragments were subjected to chemical analysis with the view of ascertaining the composition of the meteorites, and to determine what alloys exist as a rule in meteoric iron. The results of these analyses which were carried on at the Reynolds laboratory in the University of Rochester, occupy the bulk of Mr. Davison's paper. The method of examining the kamacite was interesting, as depending upon electrolysis. It was dissolved in dilute hydrochloric acid by the aid of a weak galvanic current at the positive pole of the battery. Carbon separated, and was collected on a Gooch filter and burned. The nickel and cobalt were separated from the iron by digestion in ammonium hydrate, the process being repeated four times. The iron was weighed and the nickel and cobalt first determined together by electrolysis, then separated by potassium nitrate and each determined separately in the same manner.

An Improved
Electrical Method
of Determining
Specific Heat.

AN improved method of determining specific heat by means of the electrical current, is described by Prof. Pfaundler in a recent issue of the *Wiener Berichte*. It is applicable both for direct and alternating currents, and is a modification of an older, but not very well known method. In the older method a current of electricity when passed through wire spirals, arranged in series, develops heat which is proportional in each case to the resistances. Prof. Pfaundler now substitutes small spirally coiled glass tubes filled with mercury instead of the wire spirals, and interposes these resistances as branches in a Wheatstone bridge. This device enables the older method to be more widely applied, and enables the ratio of the resistances during the passage of the current to be kept uniformly constant. Prof. Pfaundler now measures the temperature by means of the thermopile which, of course, gives much more delicate results. Slight alterations of the resistances are ingeniously, but simply, compensated for.

Fishing and the
Electric Light.

WITHIN the past two or three years the electric light has rendered considerable service in deep sea exploration, and a great deal of the information now possessed by zoologists concerning what they call the "abyssal fauna" is directly due to the use of glow lamps along with their tow or drag nets. In California, however, the electric light has recently been put to what many will consider a more practical application in this direction, namely to fishing. The sense of sight is extremely well developed in fishes, and probably is about the only highly developed sense which they possess. Years ago the Indians used to attract fish at night by the glare of torches and then spear them. When used along with the electric light most kinds of nets become simply murderous in their effects, for the brilliancy of it exercises an irresistible attraction over the fish. Salmon fishers and others who take and pack fish on the large scale are all resorting to the electric light, so that it seems not at all unlikely that, as with the buffalo, the forests, &c., so with the fisheries, this wholesale destruction will have to be restricted.

INSPECTION OF THE KARLSBAD ELECTRICAL WORKS.

[FROM OUR OWN CORRESPONDENT.]

You have recently given a description of the Karlsbad Electrical Works, and it may be interesting to your readers to be made acquainted with the decision of the experts on the several details of the inspection of these works.

The experts who acted for the municipality in the mechanical-technical department were Rudolf Doerfel, Professor in the German Technical High School of Prague, and the officially authorised inspector, Ladislaus Dix, and on behalf of the firm who rent the undertaking, the engineer, M. Kaufholt. In the electro-technical department there appeared, on behalf of the municipality, Josef Kareis, of the Royal Imperial Board of Works, attached to the Ministry of Trade, and Carl Zickler, private tutor and constructor at the Royal and Imperial Technical High School at Vienna, and on behalf of the renting firm, Prof. O. W. Kohlrausch.

The valuation took place on July 27th, 28th, and 29th of this year, in presence of the representatives of the municipality and of the renting firm, the Joint Stock Machinery Company of Nürnberg, formerly J. A. Hilpert & Co., and of the firm Ganz & Co., as having supplied certain fittings, and of experts called in by the contracting parties.

The commission met on July 27th, in the morning, in order to decide upon the order of the investigations required with reference to the points of the agreement.

After this matter had been agreed upon, the revision of the installation was commenced by testing the especial arrangements in the primary and secondary conductive net, *i.e.*, the transformer stations, the primary and secondary distribution boxes, the domestic installations, the arc lamps in the streets, as regards their construction and execution.

In the afternoon of July 27th, the revision of the central station at Doniz took place in order to decide on the general working of the entire installation. In connection with this revision there was made an observation of the normal working at Doniz, from the beginning to light up until 11.15 p.m.

On July 28th, at 7 a.m., the capacity of the central station at Doniz was tested as regards the conditions of the guarantee, section 6, *a*, *b* and *c*, with reference to the consumption of coal and the useful effect of the alternating current machines. One machine, No. 1, selected at random, was allowed to run with a full load from 8 a.m. to 1 p.m., and with a half load from 2.55 to 5.30 p.m., and was observed. On the morning of July 29th the further calculations and measurements required for checking the stipulations of the agreement, section 6, *a*, *b*, *g*, and of section 7, were undertaken in the measuring station at Neubad, whereupon the experts drew a summary of the results of their observations touching the fitness of the entire installation for being taken over, with reference to its satisfactory execution, to the observance of particular guarantees, and, finally, their requisite permanent safety, which must form a necessary basis both for the town of Karlsbad, as the possessor, and for the firm which carries on the work as tenant.

The experts of the parties interested both in the mechanico-technical and the steam engine department declare with reference to the stipulations of the agreement, and also in reply to the questions put to them by the delegates, the representatives of the municipality as regards the suitable and firm construction of the motors, and especially the accurate and permanent construction of the cylinder, the piston, &c., required for the parallel introduction of the alternating current machines, also in respect to the necessity that at a medium demand upon the alternating current machines the parallel insertion is free from objections, as follows:—

The entire arrangement of the installation of the machines, boilers, leads and auxiliary appliances agrees with the conditions demanded by the constructors of the electrical machines, as hereby the use of four engines running at a high speed seems necessitated. The number of revolutions, about 360 per minute, must be regarded as exceptionally high in comparison with other constructions. On the other hand it must be admitted that the object aimed at so that it could not be regarded as an improvement, and certainly not as a simplification of the installation, if a series of slowly-moving motor machines had been set up.

The details of the plant must be pronounced excellent, and prove a thorough experience and an equally thorough knowledge of the work. Especially the arrangement of the boilers, which enables the steam pressure required to be obtained quickly, must be pronounced very good. The arrangement of the net of tubing must be commended as very suitable as regards accessibility and safety.

As for the construction of the steam engines, the question put scarcely admitted of any other solution than the one carried out.

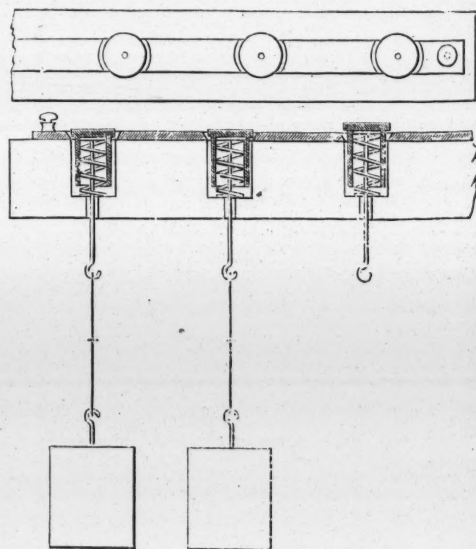
The figures found admit of the certain conclusion that the consumption of coal per indicated H.P. is within the guaranteed quantities, even in the case when the Nelson coal, burnt experimentally, should have a value of 5,500 calories, instead of the 5,000 calories demanded. The evaporation value of the coal determined at the boilers, taken in conjunction with the probable efficacy of the boilers, seem to exclude the probability that the coal in question has a still higher thermic value, and without waiting for the analysis of the coal we may state our result, which cannot be affected to a degree which would affect the accuracy of the experiments.

As regards the electric department of the installation, the experts state in detail in their report that the execution of this part may be regarded as perfectly correct and substantial, and recommend its reception as the property of the town.

AN IMPROVED APPARATUS FOR MEASURING THE SPEED OF PROJECTILES.

IN 1868 Major Le Boulengé, of the Belgian Artillery, invented a kind of chronograph for measuring the speed of projectiles. The chief feature of this device consisted in two electric circuits which were so arranged that they were successively broken by the projectile during its flight. A description of the method may be found in any of the technical works on military matters, but we may notice that the two circuits were arranged on two wooden frames in the form of wire network, and these frames were distant from each other 50 metres.

The Belgian plan seemed very well indeed for projectiles of large size, but did not give the most desirable results when small bullets were experimented with, for sometimes these would traverse the frames without rupturing the circuits. The



shape of the projectile also introduced irregularities in the method. Finally, the setting up of these wooden frames and the mending of the broken circuits took a considerable time.

In order to remedy these inconveniences a system has been worked out at the Military Academy, West Point, U.S.A., of which we now give a short description, also a plan and a section of the apparatus.

The top part of the frame through which the bullet or projectile passes consists of wood; on the upper surface of the wood strips of brass are laid down, 0.01 m. broad and 0.03 m. thick. Contact between two consecutive strips is effected by means of a small brass-capped cylinder sunk in the wood, fitted with a spring and carrying a hook, as shown in the figure. When a small weight is hanging on the hook the spiral spring is compressed, the cylinder is held down, and contact between two consecutive strips exists; but when the weight is removed, contact is broken in a way which can easily be understood on referring to the figure.

The weights used are small plates of lead, and these hang by cords from the hooks. When all the weights are hanging an electric current passes through the brass strip; but as soon as one falls, by the cords being cut, contact is broken.

The cords are arranged so closely together, that it is impossible for a projectile to pass through without breaking them and interrupting the current.

Two frames of this kind are placed 50 metres apart, and the projectile fired through them. Excellent results are obtained by this system, and the time and labour lost is reduced almost to *nil*, for it is the simplest matter possible to replace the broken threads; a number having been previously prepared, duly attached to the weights, they are simply hooked on as required.

A REMARKABLE ELECTRIC MOTOR.

By A. M. TANNER.

A FRENCH patent, granted in the year 1881, for a "perpetual electro-magnetic motor," contains such an original and fantastic preamble that I cannot resist the temptation of communicating it to your journal. It will be seen that the so-called dedication of the invention, a free translation of which is given below, is a combination of religion, patriotism, conceit, and benevolence. At all events the patentee is very sanguine that his electric motor will bring him riches which he vows to share with the poor, and then he thinks that the use of his invention will contribute to the triumph and welfare of the French Republic. I will not attempt to give a description of this remarkable electric motor, but will only say of it that the dedication thereof is its greatest attraction. It is as follows, viz.:

Dedication of my work.

I dedicate the greater part of the glory of my invention to Him who in His wise providence thought fit to inspire me. I dedicate it to a God "all powerful" and the Holy Trinity; to God the Father, to God the Son Jesus, to God the Holy Spirit. I desire that the reign of God shall arrive with the Republic, and that His holy will shall be done on earth as it is in Heaven. I dedicate my work and I confide it to God, to the Holy Virgin Mary of Immaculate Conception and Mother of God, to St. Joseph, St. Peter, St. Platon, St. Albert, St. Prudence, St. Hegesippe, St. Gantier, St. Mary, St. Madeleine, St. Agnes, St. Genevieve, St. Etienne, and to my holy patrons, Victor, Auguste, Charles, Louis, St. Vivien, St. Palais, St. John, St. Joan of Arc, I dedicate my work to all the saints, angels, and seraphims, and to the archangels, St. Gabriel, St. George, St. Michael, to the suns, the moons, the stars, the planets, and to the firmament, to all the elements and to all the works of God.

I dedicate it to France and to the Republic, and I desire that it shall contribute to its triumph and greatest welfare.

I vow to share the benefits derived from my invention with the poor and the miserable, in honour of St. Martin, God, the Holy Virgin Mary, and the heavens.

A NEW COPYING TELEGRAPH.

THE copying telegraph instruments of Bakewell, and more recently of Caselli, Meyer, and D'Arlincourt,* although they proved that the copying principle was practicable, practically never came into actual use, partly because the instruments

themselves were not sufficiently complete in detail to satisfactorily effect the object in view, and partly because no demand existed or could be created for such forms of apparatus. Quite recently Dr. Daniel H. Smith, of New York City, has applied for patents for a form of copying telegraph which, although in essential features it resembles those just mentioned, differs from them in important mechanical details, and appears to be a thoroughly practical piece of apparatus. By its means any number of copies can be produced at the same time at different intermediate points. It has been successfully worked in the United States from New York City to Buffalo—over 490 miles of line. At that distance it reproduced a fac-simile copy at the rate of 60 words per minute, a rate which the old forms of apparatus were quite incapable of. The arrangement of the apparatus is such that there seems no reason why the number of words per minute should not be increased, though this must depend upon the length of line worked.

The apparatus will reproduce drawings, characters of any description, as well as ordinary writing.

The following is a brief description of its working:—

There is a metallic table on which the matter to be copied is placed, which is worked to and fro by a motor.

A lateral movement is likewise imparted to this table by a screw, which is revolved by an escapement. The matter to be reproduced must be executed in metallic ink, so that when a point comes in contact with this ink it closes the line circuit and sends a current out to line.

The receiving instrument is the *fac-simile* to the transmitting instrument, only the pointer is elevated to allow a pen to replace it, which is fixed to the end of an armature of a small electro-magnet, so that in the movements of the table the pen at the receiving station is brought in contact with the paper when the circuit is completed at the sending station.

No one need be in attendance on these instruments, as the switches are both left to receive messages, so that when there is a message to send at any point the sender puts the transmitting switch on which replaces the pointer for the pen as described. The message is received automatically at all given points on the circuit, so that personal attention is not necessary.

THE RELATION OF VOLTA ELECTROMOTIVE FORCE TO LATENT HEAT, SPECIFIC GRAVITY, &c., OF ELECTROLYTES.

THE current issue of the *Philosophical Magazine* contains a long paper on the above subject full of experimental results by Dr. G. Gore, F.R.S. In some previous researches on changes of voltaic energy of alloys during fusion which we have already noticed in these pages, and which may be consulted in detail in the *Philosophical Magazine*, xxxii., p. 27, Dr. Gore has shown that when an alloy of bismuth, lead, tin, and cadmium, and one of bismuth, lead, and tin, changed from the solid to the liquid state by the gradual and uniform application of heat, whilst immersed in a suitable electrolyte, it suddenly increased in electropositive state, showing that, whilst absorbing latent heat, it acquired greater electromotive force, and that when these alloys solidified reverse effects occurred.

In order to ascertain whether in cases where the mere act of mixing or diluting electrolytes is known to be attended by absorption of heat, a similar increase of the power of exciting electromotive force occurs, Dr. Gore took the separate ingredients of a chilling mixture, each in a liquid state and at the same atmospheric temperature, measured the electromotive force of a simple couple of cadmium and platinum in each liquid separately by the null method of balance, with the aid of a thermo-electric pile and a galvanometer, then mixed the liquids, immediately took the temperature of the mixture, and, after having allowed the liquid to acquire the atmospheric temperature, measured the electromotive force of the couple in it.

The particulars of these experiments occupy some eight or ten pages. The following table, however, contains the chief results:

* ELECTRICAL REVIEW, December 15th, 1878, and January 15th, 1879.

Mixture.	Temperature.	Mean E.M.F.
	Degrees.	
Solution of sodium sulphate and dilute sulphuric acid	decrease 1.2 Fahr.	increase 0.0401
Liquid acetic acid + water	1.6 "	0.0730
Solution of tartaric acid + water	0.3 "	0.1923
" ammonium nitrate + water	8.0 "	0.0400
" sodium " + "	1.42 C.	0.1228
" strontium " + "	1.08 "	0.0741
" sodium chloride + "	?	0.0668*
" sulphate + "	0.14 "	0.0359
" ammonium sulphate + water	0.14 "	0.0402
" sodium carbonate + "	0.28 "	decrease 0.0445
" potassium nitrate + "	0.54 "	increase 0.0715
" ammonium chloride + "	0.19 "	0.0345
" sodium acetate + "	increase 0.14 C.	0.0360
" magnesium sulphate + "	0.22 "	0.0787
" potassium chloride + "	0.04 "	0.1219*
" sodium hydrate + "	7.14 "	0.0298
" hydrochloric acid + "	2.38 "	0.2872
" sulphuric acid + "	11.00 "	0.2375
" potassium hydrate + "	0.02 "	0.0150
" ammonia + "	0.10 "	0.0040

* In these two cases a positive plate of zinc was used.

An inspection of these results shows that in nineteen cases out of twenty, diluting an electrolyte or mixing it with another, increased the mean amount of electromotive force of the two liquids, and, secondly, that in twelve instances out of the twenty there was a lowering of temperature and an absorption of heat, and in the remainder, an evolution and loss of latent heat during the act of mixing.

Dr. Gore then set about measuring the change of volume of electrolytes by dilution, and a table of these results is given in the original paper.

On comparing both sets of results together, Dr. Gore came to the following conclusions:—

(i.) Increase of mean specific gravity of the two liquids during dilution or mixing occurs not only in cases in which heat is evolved and lost, but also in those in which heat is absorbed and becomes latent.

(ii.) Increase of mean electromotive force of the two liquids also occurs not only in those cases in which heat is absorbed and becomes latent, but also in those in which it is set free.

(iii.) In seventeen cases out of twenty an increase of mean specific gravity of the two liquids was attended by an increase of the mean amount of their electromotive force. Hence, in cases of mere physical mixture, the changes of mean specific gravity and of mean electromotive force of electrolytes are probably related to each other as concomitant effects of the same cause, change of molecular motion.

From the known general relation of increase of specific volume to decrease of specific heat, it further suggests the inference that in cases of simple dilution the mean electromotive force of electrolytes is related to their mean specific heat.

In a separate and more extensive research, not yet published, Dr. Gore says he has measured the losses and gains of electromotive force by means of different positive metals in different classes of mixture of electrolytes, including cases of chemical union as well as of mere physical mixture.

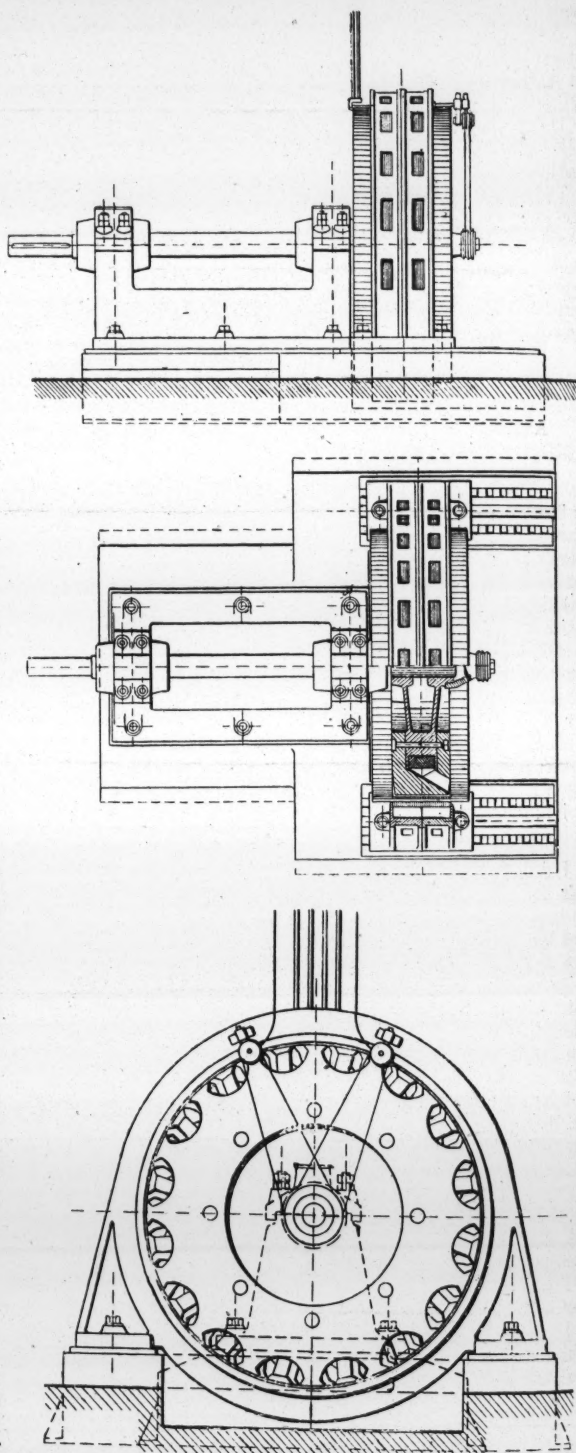
THE OERLIKON THREE-PHASE ALTERNATING CURRENT MACHINE.

OUR readers are aware that at the International Exhibition of Frankfort, the Oerlikon Works Company is showing a transmission of power experiment over a distance of 180 kilometres between Lauffen and Frankfort. The generator of this installation is a 300 H.P. machine of a new three-phase current system, and, from a set of German notices which the company has sent to us, we have compiled as well as the material would allow, the following descriptive article. The illustrations show both the perspective views of the machine with the small exciting dynamo, and the details of construction:—

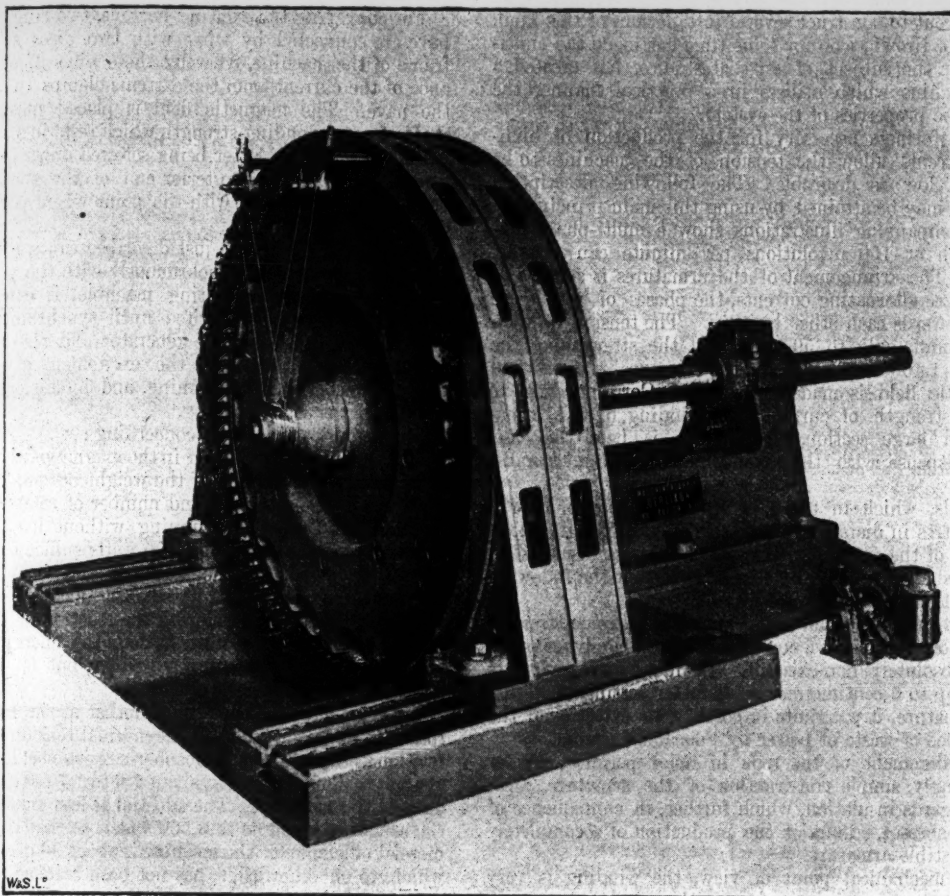
Since the transfer of work by electrical means has become

an actual fact, the question of the transmission of power to great distances, especially by the use of remote powers, comes more and more to the front.

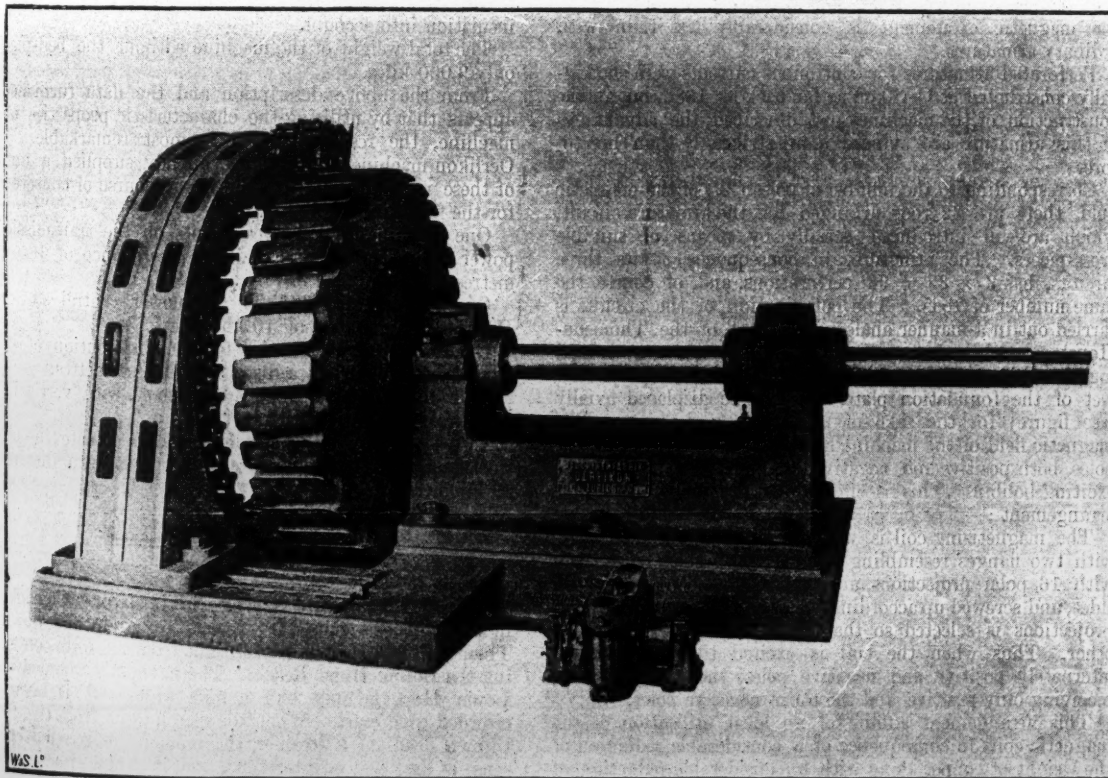
In such installations it is, as a matter of course, above all things necessary to work with currents of much higher tension than has hitherto been the case. The continuous current does not admit of such applications, whilst the alternate current affords a suitable means in virtue of its ready capability of conversion.



Further, the possibility must be afforded of working motors of whatever size in a rational manner. The simple alternating current is at present inferior in this respect to the continuous current, whilst the so-called multi-phase alternating current meets this demand in the most perfect manner.



WAS L.



WAS L.

The Oerlikon works, which from the time of their establishment have paid great attention to the electric transmission of power, is about to construct several installations of this kind. Mr. C. E. L. Brown, who for some time has made the multi-phase system the subject of especial studies, has created a type of machine which utilises in a practical manner the characteristic properties of the system.

The transformers necessary for the production of high-tension currents allow the tension of the machines to be adopted as low as desirable. The following description shows what may be attained by using this main principle.

The accompanying illustrations show a multi-phase machine which at 150 revolutions per minute can convert 300 H.P. The arrangement of the armatures is such as to generate three alternating currents, the phases of which are displaced towards each other by 120° . The tension of each current amounts only to 50 volts, and the strength of the currents is 1,400 amperes each; the armature is fixed, and the magnetic field is made to rotate. Corresponding to this great strength of current the winding of the armature has a large section, when, as it is here the case, we may dispense with the arrangement of several parallel circuits.

The leads, which in this case are massive copper rods of 29 millimetres in diameter, are placed in corresponding holes of the iron of the armature, from which they are insulated by means of asbestos tubes. By this arrangement the following very important advantages are secured:—

Foucault currents which would appear of extreme strength on the use of such massive conductors as commonly arranged are here absolutely non-existent. In fact, on experiments with bars up to 5 centimetres in diameter resting in a perforated armature, it was quite impossible to detect even the smallest trace of waste of power by Foucault currents.

The arrangement of the rods in holes permits also of an exceedingly simple construction of the armature, especially as regards insulation, which further, in consequence of the use of asbestos, admits of the production of a completely non-combustible armature.

From a mechanical point of view, the winding is very well protected against injuries from without. Displacements and injuries to the wires can never occur in consequence of overloading and short-circuiting.

Further, in consequence of the very favourable utilisation of space, and the reduction of atmospheric resistance, the magnetic excitement is considerably less than with ordinary armatures.

Perforated armatures for continuous currents were successfully constructed at Oerlikon as far back as 1885, but in the construction of the machines just described the advantages of this armature are evinced more strikingly than heretofore.

Corresponding to the number of poles (32) of the magnetic field, there are 32 rods arranged for the armature circuit, which are all introduced serially by means of suitable cross-pieces. The armature, in consequence of its three circuits, has $3 \times 32 = 96$ perforations, and, of course, the same number of rods. The combination of the circuits is carried out in a manner analogous to that of the Thomson-Houston machine for arc-lights. The iron armature is held together by a cast-iron frame, which stands on projecting feet of the foundation plate, and can be displaced axially (see figure) for the sake of mounting or cleaning. The magnetic field of the machine has the peculiarity that all the poles, both positive and negative, are produced by a single exciting bobbin. This is effected by the following simple arrangement:—

The magnetising coil is wrapped upon a cast-iron ring, with two flanges resembling a pulley; two steel rings, each with 16 polar projections, are applied to the ring on both sides, and screwed up accordingly. The position of the polar projections is selected so that they project between each other. Thus when the coil is excited there are formed alternately positive and negative poles, the one steel ring receiving only positive and the other negative poles.

This arrangement admits of an ideal utilisation of the magnetic coils in consequence of a considerable reduction of the weight of copper along with a considerable reduction of the work of excitement, as appears from the following data.

The construction of this field is of surprising simplicity and solidity, the entire magnetic field, with 32 poles, consists

only of four pieces, which, in view of the fact that the field rotates, must not be under-valued.

For conveying the exciting current, two rings fixed on the nave are connected by wires with two discs secured to the frame of the machine, whereby these wires effect the conveyance of the current from the extreme clamps to the rings of the nave. The magnetic field is placed movably upon a shaft of corresponding strength which rests in a strong double plummer block, the latter being screwed down to the foundation plate. The free, posterior end of the shaft is directly or indirectly connected with the point where power is given off or received.

Of course the machine just described can work as a motor, in which case it runs synchronously with the generator, but unlike a common alternating machine, it can start itself. The field must not be excited until synchronism has been obtained. In case that the generator and the motor are set in action simultaneously, the excitement of the magnet may be effected at the beginning, and in this case the initial tractive power is astonishing.

A few more precise data concerning:—

The total weight of copper in the magnetic field is about 300 kilos., i.e., only a fraction of the weight of copper of (other?) machines of the same size and number of rotations. It is a curious fact that when running without load, and at the normal number of rotations, 100 watts suffice to produce the tension of 50 volts in the armature, consequently only $\frac{1}{20}$ th per cent. of the full duty of the machine, certainly a surprising result. Considering the reaction of the armature when the machine is fully loaded, the energy necessary to excite the machine is naturally greater, but it still does not exceed a fraction of one per cent.

Experiments made have shown that at the full number of rotations and excitement to the normal tension the losses in friction at the bearings, atmospheric resistance, hysteresis, &c., amount to 3,600 watts, i.e., about 1.6 to 1.7 per cent. of the full duty of the machine. The additional loss in the copper of the armature amounts to 3,500 watts, so that the entire commercial efficiency of the machine is about 96 per cent., a result which, to our knowledge, has not been reached by any other machine of similar performance and speed.

Corresponding to these slight losses the heating is quite insignificant, and the machine is therefore fully competent to bear without difficulty the overloading which often occurs in industrial operations, even if we do not take the asbestos insulation into account.

The total weight of the machine without the bed-plate is only 9,000 kilos.

From the above description and the data furnished, it appears that by utilising the characteristic properties of the machine, the result obtained is most remarkable. The Oerlikon machinery works have already supplied a number of these machines, whilst others are in course of construction for the following destinations:—

One machine for the experiments on the transmission of power from Lauffen to Frankfort, a distance of 180 kilometres.

One machine for the light and power central station at Heilbronn, a distance of 10 kilometres.

One do. for an installation for the distribution of power from Dietikon-Zürich, a distance of 10 kilometres.

Five do., of which three are primary, with vertical axle and direct connection with turbines.

Two secondary, with horizontal axle to actuate the entire workshops of the Oerlikon machinery works, a distance of 23 kilometres.

Search Lights and River Navigation.—Considerable inconvenience is caused to vessels going up and down the Thames by the electric search light from the forts commanding the Lower Hope Reach. The navigable channel in the Lower Hope is only half a mile wide, and is invariably crowded with craft. When the search light from the fort is thrown dead on a steamer, the moment it is removed the sense of darkness is intensified, and if at the time a sailing vessel should happen to be quite near, there is nothing for it but to stop the engines until the effect of the brilliant light has passed away.

BRITISH ASSOCIATION FOR THE ADVANCE-
MENT OF SCIENCE, CARDIFF, 1891.

THE LONDON-PARIS TELEPHONE.

By W. H. PREECE, F.R.S.

(Read in Section G, August 24th.)

1. I HAVE already on two occasions, at Newcastle and at Leeds, brought this subject before Section G, and have given the details of the length and construction of the proposed circuit. I have now to report not only that the line has been constructed and opened to the public, but that its success, telephonic and commercial, has exceeded the most sanguine anticipations. Speech has been maintained with perfect clearness and accuracy. The line has proved to be much better than it ought to have been, and the purpose of this paper is to show the reason why.

The lengths of the different sections of the circuit are as follows:—

London to St. Margaret's Bay	84.5 miles.
St. Margaret's Bay to Sangatte (cable)	23 "
Sangatte to Paris	199 "
Paris underground	4.8 "

Total ... 311.3 "

The resistances are as follows:—

Paris underground	70 ohms.
French line	294 "
Cable	143 "
English line	183 "

Total (R) ... 693 "

The capacities are as follows:—

Paris underground	0.43 microfarads.
French line	3.33 "
Cable	5.52 "
English line	1.32 "

Total (K) ... 10.62 "

$$693 \times 10.62 = 7,359 = K R,$$

a product which indicates that speech should be very good.

2. *Trials of Apparatus.*—The preliminary trials were made during the month of March between the chief telegraph offices of the two capitals, and the following microphone transmitters were compared:—

Ader	Pencil form.
Berliner	Granular " (Hunnings).
D'Arsonval	Pencil "
De Jongh	" "
Gower-Bell	" "
Post Office switch instrument	Granules and lamp filaments.
Roulez	Lamp filaments.
Turnbull	Pencil form.
Western Electric	Granular.

The receivers consisted of the latest form of double-pole Bell telephones with some Ader and D'Arsonval receivers for comparison. After repeated trials it was finally decided that the Ader, D'Arsonval, Gower-Bell (with double-pole receivers instead of tubes), Roulez and Western Electric were the best, and were approximately equal.

These instruments were, therefore, selected for the further experiments, which consisted of using local extensions in Paris and London. The wires were in the first instance extended at the Paris end to the Observatory through an exchange at the Avenue des Gobelines. The length of this local line is 7 kms. The wires are gutta-percha covered placed underground, and not suitable for giving the best results.

The results were, however, fairly satisfactory. The wires were extended to the Treasury in London by means of the ordinary underground system. The distance is about two miles, and although the volume of sound and clearness of articulation were perceptibly reduced by these additions to the circuit, conversation was quite practicable.

Further trials were also made from the Avenue des Gobelines on underground wires of five kilometres long, and also with some renters in Paris with fairly satisfactory results. The selected telephones were equally efficient in all cases, which proves that to maintain easy conversation when the trunk wires are extended to local points it is only necessary that the local lines shall be of a standard not lower than that of the trunk line. The experiments also confirm the conclusion that long distance speaking is solely a question of the circuit and its environments, and not one of apparatus. The instruments finally selected for actual work were Gower-Bell for London and Roulez for Paris.

3. The results are certainly most satisfactory. There is no circuit in or out of London on which speech is more perfect than it is between London and Paris. In fact, it is better than I anticipated, and better than calculation lead me to expect. Speech has been possible not only to Paris but through Paris to Bruxelles, and even, with difficulty, through Paris to Marseilles, a distance of over 900 miles. The wires between Paris and Marseilles are massive copper wires specially erected for telephone business between those important places.

4. *Business Done.*—The charge for a conversation between London and Paris is 8s. for three minutes' complete use of the wire. The demand for the wire is very considerable. The average number of talks per day, exclusive of Sunday, is 86. The maximum has been 108. We have had as many calls as 19 per hour—the average is 15 during the busy hours of the day. As an instance of what can be done, 150 words per minute have been dictated in Paris and transcribed in London by shorthand writing. Thus in three minutes 450 words were recorded, which at 8s. cost five words for a penny.

5. *Difficulties.*—The difficulties met with in long distance speaking are several, and they may be divided into (a) those due to external disturbances and (b) those due to internal opposition.

(a). Every current rising and falling in the neighbourhood of a telephone line within a region say of 100 yards, whether the wire conveying it be underground or overground, induces in the telephone circuit another current, producing in the telephone a sound which disturbs speech, and if the neighbouring wires are numerous and busy, as they are on our roads and railways, these sounds become confusing, noisy, and ultimately entirely preventative of speech. This disturbance is, however, completely removed by forming the telephone circuit of two wires placed as near to each other as possible and twisted around each other without touching so as to maintain the mean average distance of each wire from surrounding conductors, the same everywhere. Thus similar currents are induced in each of the two wires, but being opposite in direction, as far as the circuit is concerned, they neutralise each other and the circuit therefore becomes quite silent.

In England we make the two wires revolve completely round each other in every four poles, but in France it is done in every six poles. The reason for the change is the fact that in the English plan the actual crossing of the wires takes place in the span between the poles while in the French plan it takes place at the poles. This is supposed to reduce the liability of the wires to be thrown into contact with each other by the wind, but on the other hand it diminishes the geometrical symmetry of the wires—so very essential to ensure silence. As a matter of fact contacts do not occur on well constructed lines, and I think our English wires, being more symmetrical, are freer from external disturbance than those in France.

(b). The internal opposition arises from the resistance, R, the capacity, K, and the electro-magnetic inertia, L, of the circuit. A current of electricity takes time to rise to its maximum strength and time to

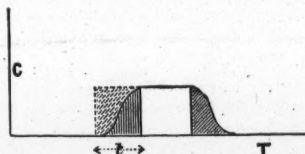


FIG. 1.

fall back again to zero. Every circuit has what is called its *time constant*, t , fig. 1, which regulates the number of current waves which can be transmitted through it per second. This is the time the current takes to rise from zero to its working maximum and the time it takes to fall from this maximum to zero again, shown by the shaded portions of the figure. The duration of the working current being immaterial and shown by the unshaded portion. The most rapid form of quick telegraphy requires about 150 currents per second, currents each of which must rise and fall in $\frac{1}{150}$ th of a second, but for ordinary telephone speaking we must have about 1,500 currents per second, or the time which each current rises from zero to its maximum intensity must not exceed $\frac{1}{1500}$ th part of a second. The time constant of a telephone circuit should therefore not be less than '0003 second.

Resistance alone does not affect the time constant. It diminishes the intensity or strength of the currents only; but resistance, combined with electro-magnetic inertia and with capacity has a serious retarding effect on the rate of rise and fall of the currents. They increase the time constant and introduce a slowness which may be called *retardance*, for they diminish the rate at which currents can be transmitted. Now the retardance due to electro-magnetic inertia increases directly with the amount of electro-magnetic inertia present, but it diminishes with the amount of resistance of the conductor. It is expressed by the ratio $\frac{L}{R}$, while that due to capacity increases directly, both with the capacity and with the resistance, and it is expressed by the product, $K R$. The whole retardance, and therefore the speed of working the circuit or the clearness of speech, is given by the equation

$$\frac{L}{R} + K R = t$$

OR

$$L + K R^2 = R t$$

Now in telephony we are not able altogether to eliminate L, but we can counteract it, and if we can make $R t = 0$ then

$$L = -K R^2,$$

which is the principle of the shunted condenser that has been introduced with such signal success in our Post Office service, and has virtually doubled the carrying capacity of our wires.

If, in the above equation, we make $L = 0$

$$K R = t$$

This is done in telephony, and hence we obtain the law of retardance, or the law by which we can calculate the distance to which speech is possible. All my calculations for the London and Paris line were based on this law, which experience has shown it to be true.

How is electro-magnetic inertia practically eliminated? First by the use of two massive copper wires, and secondly by symmetrically revolving them around each other. Now L depends on the geometry of the circuit, that is on the relative form and position of the different parts of the circuit, which is invariable for the same circuit, and is represented by a coefficient, λ . It depends also on the magnetic qualities of the conductors employed and of the space embraced by the circuit. This specific magnetic capacity is a variable quantity, and is indicated by μ for the conductor and by μ_0 for air. It depends also on the rate at which currents rise and fall, and this is indicated by the differential coefficient $\frac{dC}{dt}$. It depends finally

on the number of lines of force due to its own current which cut the conductor in the proper direction; this is indicated by β . Combining these together we can represent the electro-magnetic inertia of a metallic telephone circuit as

$$L = \lambda (\mu + \mu_0) \frac{dC}{dt} \times \beta.$$

Now, $\lambda = 2 \log \frac{d^2}{a^2}$. Hence the smaller we make the distance (d) between the wires, and the greater we make their diameter (a), the smaller becomes λ . It is customary to call the value of μ for air, and copper, 1, but this is purely artificial and certainly not true. It must be very much less than one in every medium, excepting the magnetic metals, so much so that in copper it may be neglected altogether, while in air it does not matter what it is, for by the method of twisting one conductor round the other, the magnetisation

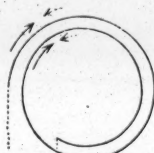


Fig. 2.

of the air space by the one current of the circuit rotating in one direction is exactly neutralised by that of the other element of the circuit rotating in the opposite direction. Now, β , in two parallel conductors conveying currents of the same sense, that is flowing in the same direction, is retarding (fig. 2), and is therefore a positive quantity, but when the currents flow in opposite directions, as in a metallic loop (fig. 3), they tend to assist each other and are of a negative character. Hence in a metallic telephone circuit we may neglect L in toto as I have done.

I have never yet succeeded in tracing any evidence of electro-magnetic inertia in long single copper wires, while in iron wires the value of L may certainly be taken at '005 henry per mile.

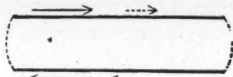


Fig. 3.

In short metallic circuits, say of lengths up to 100 miles, this negative quantity does not appear, but in the Paris-London circuit this helpful mutual action of opposite currents comes on in a peculiar way. The presence of the cable introduces a large capacity practically in the centre of the circuit. The result is that we have in each branch of the circuit between the transmitter say at London and the cable at Dover, extra currents at the com-

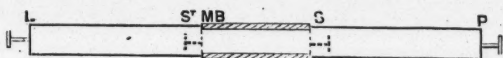


Fig. 4.

mencement of the operation, which, flowing in opposite directions mutually react on each other and practically prepare the way for the working currents. The presence of these currents is proved by the fact that when the cable is disconnected at Calais, as shown in fig. 5, and telephones are inserted in series as shown at D and D', speech is as perfect between London and St. Margaret's Bay as if the wires were connected across, or as if the circuit were through to Paris. Their effect is precisely the same as though the capacity of the aerial section were reduced by a quantity (m), which is of the same dimension or character as k . Hence our retardance equation becomes

$$R(K - m) = t$$

Thus it happens that the London-Paris telephone works better than was expected. The nature of m is probably equivalent to about '0075 ϕ per mile, and therefore k should be also about '0075 ϕ ,

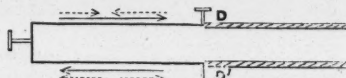


Fig. 5.

instead of '0156 ϕ per mile. This helpful action of mutual induction is present in all long circuits, and it is the reason why we were able to speak to Brussels and even to Marseilles. It also appears in every metallic loop, and vitiates the measurements of electro-magnetic inertia and of capacity of loops. Thus, if we measure the capacity of a loop as compared with a single wire, the amount per mile may be 50 per cent. greater than it ought to be; while if we measure the capacity of one branch of a circuit under the conditions of the London-Paris telephone line, it may be

50 per cent. less than it ought to be. This effect of m is shown by the dotted line in fig. 1.

Telephonic currents, that is, currents induced in the secondary wire of an induction coil due to the variation of microphonic currents in the primary wire, are not alternating currents. They do not follow the constant periodic law, and they are not true harmonic sine functions of the time. The microphonic currents are intermittent or pulsatory, and always flow in the same direction. The secondary currents are also always of the same sign, as are the currents in a Ruhmkorff coil, and as are the currents in high vacua with which Crookes has made us so familiar. Moreover, the frequency of these currents is a very variable quantity, not only due to the various tones of voices, but to the various styles of articulation. Hence the laws of periodic alternate currents following the sine function of the time fail when we come to consider microphones and telephones. It is important to bear this in mind, for nearly everything that has hitherto been written on the subject assumes that telegraphic currents follow this periodic sine law. The currents derived from Bell's original magneto-transmitters are alternate and comply more nearly with the law. The difference between them and microphones is at once perceptible. Muffling and disturbance due to the presence of electro-magnetic inertia, become evident, which are absent with microphones. I tested this between London and St. Margaret's, and found the effect most marked.

7. *Lightning.*—A metallic telephone circuit may have a static charge induced upon it by a thunder cloud, as shown in fig. 6. Such a charge is an electric strain which is released when the charged cloud flashes into the earth or into a neighbouring cloud. If there be electro-magnetic inertia present the charge will surge backward

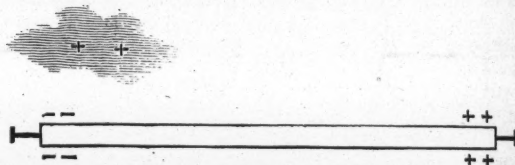


Fig. 6.

and forward through the circuit until it dies out. If there be no E.M.F. present it will cease suddenly, and neutrality will be attained at once. Telephone circuits indicate this operation by peculiar and characteristic sounds. An iron wire circuit produces a long swish or loud sigh, but a copper wire circuit like the Paris-London telephone emits a short, sharp report, like the crack of a pistol, which is sometimes startling, and has created fear, but there is no danger or liability to shock. Indeed, the start has more than once thrown the listener off his stool, and has led to the belief that he was knocked down by lightning.

8. The future of telephone working, especially in large cities, is one of underground wires, and the way to get over the difficulties of this kind of work is perfectly clear. We must have metallic circuits, twisted wires, low resistance, and low capacity. In Paris, a remarkable cable, made by Fortin-Herman, gives an exceedingly low capacity, viz., only '069 ϕ per mile. In the United States they are using a wire insulated with paper which gives '08 ϕ per mile. We are using in London Fowler-Waring cable giving a capacity of 1.8 ϕ per mile, the capacity of gutta-covered wire being 3 ϕ per mile.

THE CAUSES OF VARIATION OF CLARK STANDARD CELLS.

By J. SWINBURNE.

(Read in Section A, August 25th.)

It is well known to those who have worked with them that Clark standard cells are not yet to be trusted in very accurate work. It is quite easy to make up a few cells which agree among themselves, but they seldom agree with others made up at different times with different chemicals by different people, and they often take long to "settle down." No one who wanted a standard within less than one-tenth per cent. would set up a Clark and trust it without comparing it with other cells. The measurement of electromotive forces can easily be made within not only one in a thousand, but one in a million, and as we already have accurate resistances, a standard cell giving even approximately accurate results would be of enormous value.

It, therefore, seemed worth while to investigate the causes of variation of Clark cells. Such an examination must necessarily be laborious and it took up a great deal more time even than I expected. I must also pass over a great deal in order to confine my paper within the limits usual at the British Association.

The Clark cell has already received the most careful attention from Mr. Latimer Clark and Dr. A. Muirhead, who has, I believe, already gone thoroughly into the chemistry of it; and from Messrs. Wright and Thomson. Lord Rayleigh has, perhaps, gone into the matter more carefully than anyone else; and Messrs. Carhart, Dearlove, Skinner, Fleming, Crompton and very many others have worked at the same subject.

The method I have followed is to take the various parts of the cell separately, beginning at the zinc and eliminating the rest of the cell.

The cell taken as standard throughout most of this investigation was made in strict accordance with the latest Board of Trade Committee's circular. Two were made at the same time, and one, No. 1,614, was sent to the committee, while the other, No. 1,615, was kept for reference. They agreed nearly enough to give no deflection

when coupled back to back through a 100 ohm reflecting galvanometer. I have not yet heard how this cell agreed with the committee's standards.

My arrangement for measuring electromotive forces would read about 0.000002 of a volt, but it was useless taking such accurate readings generally, as the last few places of decimals were nearly always swamped by errors due to variations of temperature coefficients. The accuracy of reading is enormously greater than that of the cells to be read. In many cases, however, the internal resistances of the cells were very great, and readings could be taken within a few places of decimals only.

Cell No. 1,615, or as I may call it for reference, the B.O.T. cell, was always kept in the water bath, in which all cells under examination were left. All the apparatus was insulated by being fastened to celluloid plaques fastened to the wall, or by standing on celluloid mats. I had no leakage.

VARIATIONS DUE TO ZINC.

The following zincs were tried:—1,620 and 1,625 from Townson and Mercer, labelled "free from arsenic"; 1,621 "pure," from Hopkin and Williams; 1,622 Becker's second quality, 1,623, roofing zinc. These were first filed and sand papered, washed in caustic soda, dried with filter paper, washed with dilute sulphuric acid and then with distilled water. This is the orthodox way of preparing zincs. It is much quicker to dip them in strong nitric acid which gives a surface like silver at once if the zinc has not been amalgamated. These zincs were suspended in a carbonic acid flask in a saturated solution of zinc sulphate which had been shaken up with barium carbonate and filtered. I need not give the tables of readings of these zincs. At first they varied about 0.4 per cent., that is to say, they would have caused variations of 0.4 per cent. of the electromotive force of a complete cell. The variation increased to more than half per cent. I did not take readings of over a half per cent. Sometimes one zinc was higher, sometimes another; and on shaking the flask a little the readings were altered. This behaviour was partly due to impurities, probably iron, in the zinc sulphate. On shaking, a new clean surface of zinc was wetted and exposed. A black high water mark appeared on the zincs after some time.

The zincs were cleaned again and dipped for a moment in a weak solution of acid mercuric sulphate and washed. They were thus very slightly amalgamated. They were tested in solution 1,628, nearly free from iron; 1,622 and 1,625 then read 1.00005, while 1,620, 1,623 agreed with 1,621, which was taken as standard. These measurements can be taken with great accuracy, as the resistances in circuit are low. 1,620 and 1,625 were pieces of the same rod of zinc. After an hour the zincs came within about four in a million. One of them, 1,625, was then thickly amalgamated by dipping in acid mercuric sulphate. Drops of mercury hung to it. It read 0.999910, 0.999976, 0.999988, and finally one in the course of two minutes. The zincs were then put back into solution 1,624 which gave so much trouble before. They now read within one or two in a million. After standing for nearly three weeks they were marked all over, and varied nearly a tenth per cent. among themselves, and more than that compared with 1,621, which had been in another solution acting as a standard in other experiments.

From this it appears that in order to give good results the zincs should be heavily amalgamated. If thoroughly amalgamated practically any zinc will do. The zincs which gave low electromotive forces were always the small ones, that is to say, those which would get the thickest coatings of iron.

To find out whether amalgamating altered the readings an amalgam was made by touching mercury with zinc. It was more than a half per cent. wrong. After dissolving more zinc, the reading was still low, though by stirring in zinc it soon came up to 0.99984 and 0.99994. A series of amalgams was made containing 25, 12½, 5, 2½, and 1 per cent. of zinc and one with less zinc. These were put in solution 1,628 of zinc sulphate with little iron. The solution was poured in and out many times to secure homogeneity, an important matter to which I will return. The readings obtained were—

25 per cent.	1.000025	and	0.99999
12½	"	1.00008	" 1.000000
5	"	1.000035	" 1.000010
2½	"	1.00005	" 1.000020
1	"	0.997225	"
trace	below	0.995	

The second readings, which were taken a few minutes later, are close enough. Amalgams therefore having some 2½ per cent. of zinc will do. Lord Rayleigh has done a great deal of work on amalgam cells, and he found the amalgam always cracked the tube. I made one H-cell with amalgam in 1888 which had the platinum led out at the bottom, but it did not crack. I made several other cells at the same time with an internal test tube to hold the amalgam, and none of them cracked. On the other hand the 5 per cent. amalgam broke its test tube. I would suggest that platinum sealed to German glass is always left under constraint, and the crystallisation of the zinc also adds pressure which cracks the tube. My H-cell had a little lead glass just round the platinum; moreover it was very small. The 2½ per cent. amalgam is liquid, so there is no danger from it.

To sum up as to the zinc, then, I would suggest that if rod be used it should be well amalgamated first. It is gradually amalgamated in the cell, but this process is slow, especially if the solution contains basic zinc sulphate. The gradual amalgamation is probably one process that makes many cells take a few weeks to arrive at final values. If zinc rod is used, it would seem better to use platinum, silver or zinc wire to make connection, and to avoid solder, otherwise it is only a matter of time till the zinc falls off. All these troubles are swept away by the use of zinc amalgam, as proposed by Lord Rayleigh. There is another reason in its favour to be mentioned under the head of temperature coefficients.

THE ZINC SULPHATE SOLUTION.

The chief difficulty arises from the presence of iron. Samples were bought from Messrs. Hopkin and Williams and Becker. These both contained iron. Iron is often to be seen as a deposit after shaking up with zinc "carbonate." Some sulphate of zinc was made by dissolving "pure" zinc in redistilled sulphuric acid. Provided there is always excess of zinc, one would expect little iron. Another batch was made by leaving excess of commercial granulated zinc in dilute commercial acid, which itself contains iron. Neither of these had enough iron to blacken zinc. None of the samples of zinc sulphate blackened copper. When I say that samples of sulphate of zinc bought as pure from such people as Messrs. Hopkin and Williams contain iron, I mean that they contain enough to cause variations in cells, not enough to get precipitates of prussian blue. Zinc or barium carbonate might be expected to precipitate all the iron. It does not however. Probably carbonate of iron really exists and remains in solution. In experiments on alkaline secondary cells with iron plates, I produced a green compound which appeared to be a real carbonate of iron. The best method of dealing with iron is to acknowledge its presence and amalgamate the zincs. The best zinc sulphate solutions I used were obtained by dissolving granulated zinc in dilute commercial acid, keeping the zinc in excess. Solution 1,628, already mentioned, was made this way. Of course, pure zinc and acid may be used. This method produces basic sulphate, too, especially if hot. This can be afterwards neutralised by acid.

It is usual to shake up zinc sulphate with "carbonate," and to filter before use. This is probably because the sulphate reddens litmus paper. Neutral zinc sulphate reddens litmus paper, however, so there seems little reason for adding zinc "carbonate." I imagine that any salt, which can give up a little acid by forming a basic salt, will redden litmus. The sulphate can be neutralised by being left in contact with zinc. A solution that is strongly alkaline to methyl orange reddens litmus paper. What is bought as zinc "carbonate," is either a basic carbonate or a mixture containing oxide. There are some half-dozen basic sulphates of zinc, and shaking up with "carbonate" forms some of these. The presence of basic sulphate in the solution prevents the mercury salt getting to the zinc to amalgamate it. Mercurous sulphate is, I believe, split up by water into basic and acid mercurous sulphate. Basic zinc sulphate precipitates any normal mercurous sulphate that may be dissolved, and the acid sulphate as basic mercurous sulphate or as mercurous oxide. This accounts for the dark gray deposit often seen on the top of the paste in cells prepared in the usual way. The mercury salt thus cannot get to the zinc till the whole of the basic zinc salt has been used up.

In order to test the effects of various solutions of zinc sulphate, test-tubes with feet were filled with the solutions, and were connected with the standard solution by a siphon tube. This had one end blocked with filter paper to prevent mixture of solutions. It is needless to give tables of readings. Anomalous results were obtained at first, but they were all traceable to the zincs. After amalgamation, all the saturated solutions gave the same readings within a few in a million. 1,621, made by dissolving pure zinc in acid, was 100 in a million too low.

To test the effect of acid I added a few drops of "normal," that is, very dilute sulphuric acid, to a saturated solution of Hopkin and Williams's zinc sulphate. The solution was then strongly acid to methyl orange. The solution read 1.001200 against zinc 1,621 in some more of the same solution. On neutralising with zinc "carbonate" the reading was 1.001100. Free acid appears to make little difference. This experiment was repeated with new solutions. The two zincs were first tested in the same solution. One gave about eight in a million; this was moved into the other tube, B, of the same solution and taken as a standard. The reading was now 1.000110 for A. Five drops of pure acid were put in a small test tube, and a little of A added, and the tube cooled. Then the acid was added to A, which became strongly acid to methyl orange. The reading was now 1.000000. The liquid was then shaken up with zinc carbonate till alkaline to orange, and the reading rose to 1.00009. On the other hand, a solution which had been left in contact with excess of zinc carbonate for some weeks gave no deflection. In any case the zinc will eventually use up any free acid. These anomalous results may be partly due to slight differences of density in the solutions, and partly to unascertained causes.

This is the last point that need be mentioned in connection with the solution. The solubility of zinc sulphate varies enormously with the temperature. If a tube of it is left with crystals at the bottom, when it comes to a low temperature all the crystals collect at the foot. When the temperature rises the upper part can only become saturated again slowly by diffusion. To test this, two zincs were put in a test tube of saturated solution with crystals at the bottom. After a few days the top zinc gave 1.0005 compared with the bottom. The lower zinc was then raised, reading 1. The other zinc was then depressed, reading 0.999475. The difference of density thus causes an error of 5 in 10,000. This tube was some 10 cm. long, so the error in standard cells may not be so great as this, still diffusion is very slow even in a short cell. This also influences the temperature coefficient. The question of supersaturation has already been dealt with so thoroughly by Lord Rayleigh, that I saw no use in experimenting on it. There are some half-dozen hydrates and an anhydrous sulphate of zinc. If the solution is not heated above blood heat the Zn SO₄ 7H₂O crystallises out.

To sum up: the chief errors caused by the solution are due to traces of iron and variations of density. The zinc should therefore be amalgamated. I would suggest that zinc carbonate be omitted. To avoid changes of density, if a saturated solution is imperative, a zinc amalgam must be employed with crystals lying on its surface. This can be done in one of Lord Rayleigh's H cells, or a smaller tube can be slipped into the cell. The surfaces must be on the same level, else all the crystals will collect on the lower one, as that lowers the centre of gravity of the system, thus doing work. A small test tube

full of crystals was put inside a larger tube of saturated solution, and this action was found actually to take place.

There is some further complication between the zinc and its solution. Even amalgams will give very large variations if moved about in the solution. This is the case even with dilute solutions. I can scarcely hazard a suggestion. Some Lippman effect may be produced by shaking the amalgam. This does not seem at all likely. It is possible that zinc, even when amalgamated, will dissolve in sulphate, forming basic sulphate, provided the zinc is moved so that the hydrogen can get away in solution, as it cannot come off in bubbles. Ordinary zinc will dissolve in boiling zinc sulphate solution, the solution turning milky on cooling; but I cannot make out whether amalgamated zinc does or not. In the cold it gives off bubbles slowly. I do not know whether any surface boundary layers can cause such effects; whether there is an action like that in a frictional electric machine going on.

MERCURIUS SULPHATE.

Samples of mercurous sulphate were bought from Messrs. Becker and Hopkin and Williams. I also had some samples from Hopkin and Williams, Becker and Griffin, bought in 1888, and some I made myself at the same time. I also prepared some new specimens by heating in an oven a flask with mercury twice distilled in vacuo and redistilled acid. The temperature was kept at 125° C. by a mercury regulator, and only a portion of the mercury was dissolved. The sulphate was washed with distilled water and dried. It is in white crystals. Other samples were made by dissolving mercurous nitrate in water slightly acidified with nitric acid, and precipitating with zinc sulphate. This is perfectly white unless much washed. A yellow colour then appears.

There are several sulphates of mercury. There is mercuric sulphate, which, on shaking up with water, splits into acid mercuric sulphate, which is soluble, and basic mercuric sulphate, which is a bright yellow insoluble powder. There is, I believe, a mercuric-mercurous sulphate. I do not know it, nor do I know if there are acid and basic salts to correspond. There is also mercurous sulphate, which some say is soluble in water, but which, I believe, splits up into acid mercurous sulphate, which is slightly soluble, and basic mercurous sulphate, which is a dirty yellow powder. In testing the pastes, some of that used for the B.O.T. cells was used as a standard. Zinc No 1,621 was kept in a solution of sulphate, and was connected by a siphon with the tube of standard paste, the cell thus made being checked against the B.O.T. standard. After a few days there was never any deflection. The pastes could not be measured so easily as zincs or solutions on account of their high resistance. There is also frequent trouble from want of contact with the platinum wires. Merely heating these and dipping in mercury is not always enough. I found it better to bend the platinum into an eye and to boil it in mercury, and not to consider it amalgamated till it took up a film of mercury with it, or to use sodium amalgam. The siphon tube was no longer stopped with filter paper, so its resistance was lower. Some of the experiments on pastes are given in the following table:—

water and the solution precipitated with salt and filtered. The filtrate was tested with hydrogen sulphide and with potassium iodide. This paste seems right.

1,655.—Paste bought in 1891 from Becker. This was a white powder, and remained white as paste. Contained no persalt. Gradually fell to normal. The pastes nearly always give high readings after stirring up well.

1,656.—Paste from Hopkin and Williams, 1891. Powder, grey, turning yellowish in the paste, contains a great deal of persalt. This is the paste generally used for cells. Two other specimens bought from the same firm some years ago also contained persulphate. The paste begins very high, gradually falling. Washing out the persulphate may help this. I do not know if sodium formate could be used to reduce the persalt.

1,657.—Paste from Griffin. Grey powder. Contains a great deal of persalt. On July 24th, 1891, excess of zinc carbonate was added to this paste. It frothed up and remained as a sort of sponge. The reading then fell gradually till it was too low.

1,658.—Paste made by slow electrolysis. M. Potier has proposed a cell made by using a mercury anode and cathode in zinc sulphate; but I have not the reference. The zinc amalgam is, of course, too weak unless a great deal of electricity is passed through. The paste formed is the yellow basic mercurous sulphate. The reading was too high first, and fell to nearly normal. Finally a little acid was added on August 2nd, 1891, and the reading was very high. I made other unsuccessful experiments on Potier cells.

1,612.—H-cell with 2½ per cent. amalgam. It was always low, probably because its solution was saturated at both poles. Of course, as this was a complete cell it was compared direct with the B.O.T. cell, and as the temperature coefficients are different, and as there are other causes of variation it is impossible to say which was at fault. Readings like those of 1,654 may be got with pastes, but not with different kinds of cell.

1,674.—Becker paste, 1888, with zinc carbonate.

1,675.—Same without carbonate. Probably there was not enough carbonate to convert the whole of the sulphate into basic salt. Lord Rayleigh recommends the addition of a very small quantity of zinc carbonate to the paste. If the paste has persulphate the carbonate will first convert it into basic persulphate, which appears to be harmless. An excess of zinc carbonate will, of course, waste the mercurous sulphate.

1,679.—Complete cell with Becker paste; put in dry.

1,681.—H cell. Becker paste.

1,685.—Paste made by electrolysis in acid solution.

1,688.—Tube cell, with precipitated mercurous sulphate, made in 1888.

It will be seen that the cells seem to tend towards a common value, but that is almost all that can be said.

The Board of Trade circular directs the paste to be rubbed up with mercury. This would tend to reduce the persulphate to protosulphate. Mercury cannot be rubbed up with protosulphate, as it does not oxidise the surface, so the mercury is not "killed," and collects in a

TESTS OF PASTES AND CELLS.

Number.	22/7/91.	23/7/91.	24/7/91.	24/7/91.	25/7/91.	29/7/91.		30/7/91.	2/8/91.	
1,650	0.9994	...	0.99975	1.00000	1.00000	Quiet.	Agitated.	1.00000	Quiet.	Agitated.
1,651	High.	...	High.	High.	High.	1.00000	...	...	1.00000	...
1,652	No circuit.	...	Low.	Low.	Low.	High.	...	...	...	...
1,653	0.99965	...	0.9995	0.9997	0.9997	Low.	...	...	...	...
1,654	1.00000	...	1.00000	1.00000	0.99989	0.99953	0.99979	0.99999	1.0010	...
1,655	1.0003	...	1.00002	1.00000	1.000014	1.00000	...	...	1.00000	...
1,656	High.	...	High.	1.0012	1.0011	1.00000	1.000077	...	...	...
1,657	High.	...	High.	High.*	1.0011	1.00042	1.00091	1.00025	1.00045	1.00045
1,658	...	High.	1.00235	1.0004	1.00143	0.99867	Low.	...	...	...
1,612	...	0.99775	0.99725	0.9994	...	1.00077	...	...	1.00158	1.0021
1,674	...	...	...	1.00015	...	...	...	...	...	...
1,675	...	...	...	1.00000	1.0007†	0.99951	0.99923	...	0.99965	0.9993
1,679	...	...	...	...	...	0.99951	0.99951	...	0.99925	0.99915
1,681	...	...	...	...	...	0.999272	0.999065	0.99927	0.99925	...
1,685	...	...	...	...	...	1.00043	...	...	...	...
1,688	...	...	...	...	...	...	...	...	0.99698	0.99693
									0.99875	0.9985

* Shaken up with zinc carbonate.

† Not altered by shaking up.

1,650 was B.O.T. paste. Its readings are given in terms of 1,615, the B.O.T. standard. The other pastes are given in terms of 1,650. Columns 1, 2, and 3 are not corrected for the variation of 1,650, as from the readings of 1,653, 1,654, and 1,654 it looks as if the B.O.T. cell had been varying owing to alterations of density of the zinc sulphate solution.

1,651.—Paste given to me by Mr. Fox Bourne. The bottle had Becker's label, but the paste was grey like that of Hopkin and Williams, from whom Mr. Fox Bourne had also bought sulphate. It was always far too high.

1,652.—Paste of basic mercuric sulphate. This was always very low. This goes to show that basic mercuric sulphate is harmless, so that mercuric sulphate may perhaps be rendered harmless by washing it thoroughly.

1,653.—Paste made by dissolving mercury as already described. It began low, gradually coming to be too high on shaking.

1,654.—Paste by precipitating mercurous nitrate with zinc sulphate. This is quite white, unless copiously washed, then it is slightly yellow owing to the presence of basic proto-sulphate. Tap water containing chalk must not be used for washing. This paste contains no mercuric salts. To test the pastes for mercuric salts, they were shaken with

globule. The mere fact of the mercury mixing shows that the sulphate is bad.

MERCURY.

To test the effect of impurities, some amalgam containing silver, copper, and zinc was taken. Sodium amalgam was added, and the whole shaken up with salts of lead, iron, antimony, platinum, and tin. The amalgam was then shaken up well with persalts of mercury. The mercuries to be tested were put in little crucibles in a solution of mercurous nitrate. After a few minutes they all agreed.

TEMPERATURE COEFFICIENT.

The temperature coefficient of several cells was taken with some care. Three cells were tested first. They were put in a bath at about 30° C., the temperature being taken at each reading, and the water slightly stirred.

1,682	...	0.000312 and 0.000340
1,684	...	0.000861 " 0.000840
1,683	...	0.000297 " 0.000308

The reason for the discrepancy between the first and second reading of each cell is clear; the cell was colder than the water at first, then

as the cell warmed and the water cooled, the cell was left a little hotter than the water in which the thermometer was placed. Some days later the following readings were taken. In this case I kept the temperatures nearly constant by adding hot water.

1,680	...	0.000287	1,685	...	0.000492
1,682	...	0.000421	1,688	...	0.00085
1,683	...	0.000324	1,689	...	0.00042
1,684	...	0.000756			

Of these cells, 1,680, 1,683, 1,689, had dilute solutions, made up of equal weights of water and $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$. 1,680 and 1,683 differed only in the mercury paste; 1,683 gave different coefficients on the two days. The variations in the other cells may be easily explained. If a cell with the zinc at the top has its solution saturated at, say, 15°C ., and is then heated, the solution round the zinc is no longer saturated. The temperature coefficient of the cell depends on its past history in fact, and is lower in spring than in autumn. An H cell, or a tube cell, with crystals of zinc sulphate in contact with the zinc always has its solution saturated at both plates. 1,682 is an ordinary cell, but the zinc is at the top, hence its low temperature coefficient when heated. If left at 30°C . for a few weeks and then cooled, no doubt its temperature coefficient would rise to 0.0008 or 80. 1,684 is an H cell, with crystals in both legs. 1,685 is an electrolysis cell, with zinc at top. 1,688 is a tube cell, with crystals in both tubes, hence its high coefficient. It is thus clear that the tempe-

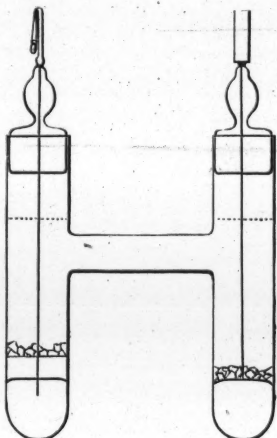


Fig. 1.

perature coefficient of a cell may vary from day to day according to its treatment, and may, perhaps, vary 100 per cent. between winter and summer. Even a variation between .0008 and .0006 means an error that may in extreme cases amount to something like a half per cent., that is, it may be outside the limits I have here taken as worth considering. My water bath differed some two or three degrees from one evening to another, and, no doubt, varied more during the day and night. A new cell would thus be saturated at, say, 20° , while the standard was saturated at, say, 15° . If the coefficient of one was 0.0008 and of the other 0.0004, the error might easily be 0.0012 due to that alone. To avoid this difficulty the solution must be kept satu-

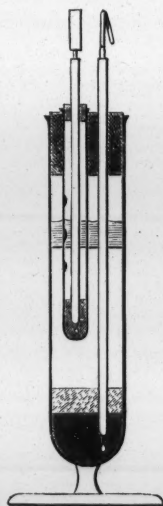


Fig. 2.

rated by using the H or tube cell. Some authorities push the zinc into the paste. This may give the same result, but the zinc then amalgamates too much. Sometimes it has beads of mercury hanging to it, and if these are the only surfaces exposed, the electromotive

force may be too low. Over amalgamation also often detaches the zinc by weakening the solder. Moreover, the formation of so much zinc sulphate may use up all the water, thus rendering the cell dry, or producing a less hydrated salt.

It would seem better to use a weaker solution. Prof. Carhart and others have proposed saturating at 0°C . It seems much simpler to use a standard solution of sulphate made by weighing. There is no particular advantage in saturating at 0°C . Weak solution cells have the very great advantage of low internal resistance. No doubt, crystals of zinc sulphate also lessen the available surfaces of the metals and lessen the current that can be taken without polarisation.

The construction of the H cell is shown in fig. 1. One leg contains amalgam with crystals on it, and the other paste. Platinum wires are sealed through glass stoppers, and end in little bracelet snaps. The stoppers are smeared with vaseline to prevent creeping. Fig 2 is a tube cell. A test tube with a foot has a cork with two holes in it. Through one of them the tube with internal wire is led to the bottom. The mercury and paste are poured in through a funnel. The zinc tube is then pushed through the larger hole in the cork; it contains the amalgam, and has three holes in the side. It is strong to resist fracture. Solution is poured in gently above the level of the first hole. Rangoon oil is poured in over the level of the second hole. The third lets the air out. The zinc connection is then put in, with its cork fitting the smaller tube. If the solution is saturated, the inner tube must be long, so that the zinc surface is on a level with the crystals on the paste. If a dilute solution is used, the inner tube is shorter. This form of cell is convenient for immersing in a bath, and the zinc tubes can be taken out and changed, or tried in other cells.

Prof. Carhart mentions the effect of pressure on Daniell cells. I tried exhausting a Clark cell a third of an atmosphere, and raising its pressure, but though that must have affected the tendency of the liquid to evaporate, it made no perceptible difference in the reading.

Though tube cells with dilute solutions and pure mercurous nitrate agree within one in a hundred thousand it is desirable that such cells should be made up by different people. The question of the methods of making up standard cells should therefore be taken up by a committee.

THE MEASUREMENT OF LIQUID RESISTANCES.

By J. SWINBURNE.

(Read in Section A, August 22nd.)

THE great difficulties in measuring liquid resistances arise from polarisation at the electrodes. Various methods of eliminating the errors arising from polarisation, and from variations of surface resistance due to bubbles have come into use; the most usual being to employ an alternating current and a telephone.

The following are some methods of avoiding polarisation errors in a manner analogous to that employed by Sir William Thomson, Mr. Heaviside, and others, in measuring low resistances. In measuring low resistances, the resistances of the contacts are high in comparison, and have to be eliminated. Fig. 1 shows the vessel employed. It

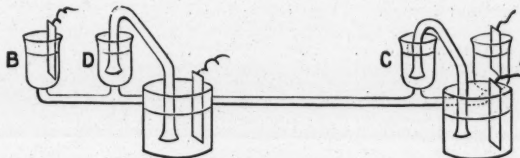


Fig. 1.

consists of a glass tube, with cups, A and B, at the ends, for the main electrodes. Near the ends are feeler cups, C, D, and it is the difference of potential of these feeler cups that is measured. They are connected by means of parchment siphon tubes, such as those used in Raoult's cell, with vessels containing electrodes in a suitable electrolyte. For instance, suppose the resistance of sulphuric acid is to be measured. The main electrodes are platinum or lead. The siphon

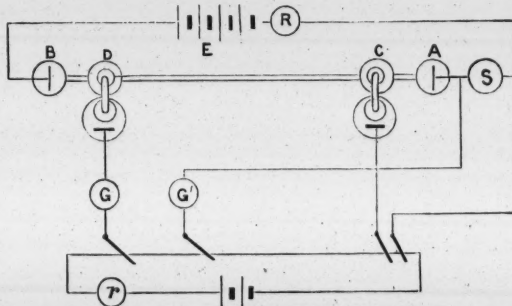


Fig. 2.

tubes are filled with acid and connected to vessels filled with sulphate of zinc. The electrodes in these are zinc amalgam. The apparatus may be arranged either so that there is no current from c to d, or so that there is a current which may polarise the amalgams a little. In this case the polarisation can be observed. Fig. 2 shows a method

with no current. The main circuit from the battery, *E*, is through a resistance, *R*, which is fairly large, so that variations of resistance or back pressure elsewhere in the circuit do not affect the current much. Then it passes through a standard resistance, *S*, to the main electrode, then through the tube back to the battery. The fall of pressure between the feelers, *c* and *d*, is compared with that over the standard resistance, *S*, by means of the potentiometer arrangement shown diagrammatically. For accurate work a resistance box is used; the wire is only shown for clearness. In this case there is no current in the feeler circuit, and, therefore, no polarisation. A deflection can be taken on each side of zero if desired, so as actually to reverse the current. Polarisation of the feeler electrodes can also be detected instantly by breaking both the cell circuits. There should then be no deflection. The drawback to this method is that successive readings have to be taken, and if bubbles are coming off the main electrodes, the main current can never be quite constant. Fig. 3 shows another disposition with a differential galvanometer, whose coils are lettered *G H*. In this case there is a current in the feeler circuit. To make sure that it produces no error the direction of the main current is commuted quickly at *K*. Any polarisation then gives a double deflection. The apparatus may also be coupled up as a Thomson low resistance bridge. By varying the number of cells Ohm's law can be checked. As Prof. Strand has pointed out to me, the resistance of the siphon tubes must be included in the galvanometer circuit, and it is unknown. It can be made inappreciable.

Amalgamated zinc does polarise slightly, or some other action takes place which produces an equivalent result. Unless the time of contact is long, however, it does not give rise to trouble. Polarisation shows at once by the deflection on lifting the main key.

The main tube is calibrated by lifting it with mercury. Mine is

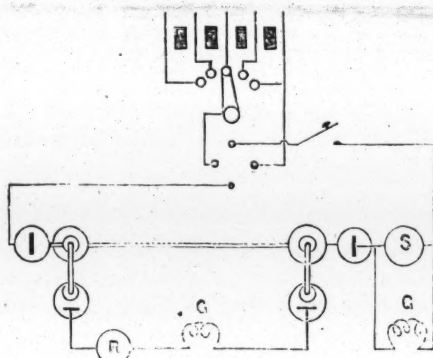


FIG. 3.

straight, but it would be better to coil it up to go into a water bath easily. If one siphon tube is not enough a second intermediate tube with a vessel can be used. I think one is generally enough, however. For instance, for measuring caustic sulphate of soda would be used in the siphon tubes, and so on. I have not experimented on various electrodes yet. Amalgams of silver or copper in suitable solutions, or mercury in mercurous nitrate may be better than zinc amalgam in zinc sulphate.

ELECTROLYTIC PROBLEMS.

By ROBERT L. MOND, B.A., F.R.S.E.

(Read in Section A, August 22nd.)

THE study of Clerk Maxwell's theory of the propagation of electric energy through the dielectric along conductors having, through the magnificent experimental work of Hertz, emerged from the purely mathematical stage, it may be of interest to apply it to the elucidation of the phenomena occurring on the propagation of electric energy through that class of conductors known as electrolytes.

The propagation of electric energy along metallic conductors is invariably found to produce the following four phenomena:—

- I.—The electric energy is propagated with the velocity of light.
- II.—An electro-magnetic field is produced.
- III.—Induced currents are produced in neighbouring conductors.
- IV.—Heat is produced in the conductor uniformly along its length proportional to the strength of the current and the resistance of the conductor.

These four phenomena are also produced during electrolysis; they are, however, accompanied by a fifth phenomenon, namely, chemical decomposition at the electrodes, and this chemical decomposition is strictly proportional to the strength of the current, but not to its intensity.

Hence, by infinitely increasing the potential and diminishing the strength of the current, we can make the absorption of electrical energy due to chemical action as small as we please; and thus we can establish so complete an analogy between the propagation of electric energy along metallic conductors and along electrolytes that any views brought forward to explain the phenomena in the one case must perforce apply to the other.

The theory of the propagation of electric energy along metals has been thus concisely defined by Prof. J. J. Thomson:—

"The velocity of transmission of an electric impulse along a wire is, according to Maxwell's theory, equal to the velocity with which light passes through the dielectric in which the energy resides, and

the function of the wire seems merely to be that of guiding the discharge which travels at a rate fixed by the dielectric.

Prof. H. Hertz has recently shown that when an electric oscillation travels along a wire the electric force produces a mechanical effect at right angles to the wire, whilst the magnetic force which accompanies it tends to repel a ring brought into its vicinity; thus there are two vibrations perpendicular to each other, the nodes of the one coinciding with the antinodes of the other, passing along the wires, whence he concludes that "from the above experiments with conductors of very simple form it is evident that a conductor of any form, when placed in the path of electro-magnetic waves, is subject to forces of a very complex character."

Since a guiding conductor surrounded by dielectric is required (according to the above theory) for the propagation of electric energy in definite directions, the question arises, "How can an electrolyte act as such a guiding conductor?"

For this there are two possible explanations. Either (I.) the bulk of the electrolyte might be considered the conductor, and the surrounding medium the dielectric, such as glass or air; or (II.) in the electrolyte itself a rearrangement of molecules is produced, some (i.e., the best conducting) forming the guiding conductors along the lines of force between the electrodes, others dielectric tubes surrounding the same.

The first proposition is untenable, for, although it explains how an electro-magnetic field may be produced outside the electrolyte, it utterly fails to explain how a fairly uniform field is produced inside it.

Molecular chains have formed the basis of every theory of electrolysis since they were first proposed by Grotthuss, although the mode of action of the molecules has been explained in a great number of different ways.

The molecular arrangement required for the second proposition, i.e., molecular chains surrounded by dielectric tubes, was first proposed by Prof. G. Wiedemann, who brings weighty proofs in its favour, but who also, like his predecessors, assumes that the current passes through the molecular chain. He has, however, provided the requisite mechanism for the application of Clerk Maxwell's theory to electrolysis.

The electric energy in being propagated through these dielectric tubes along the chain of conducting molecules produces these magnetic and electric effects which act chemically on the dielectric, decomposing the molecules into atoms, or weakening their affinity along the zones of intense electric action surrounding each molecular chain. A similar view was already suggested by Faraday, when he considers the electric current to be "an axis of power having contrary forces exactly equal in amount in opposite directions," modifying the chemical affinity of the electrolyte in directions parallel to the axis, and providing the conditions for the transfer of electro-positive and negative ions in their respective directions.

That there is a tendency for a strong electric field to produce molecular decomposition is evident from the action of the silent discharge and the electric arc, and also from such observations as those made by Bouty of electrolytic action on the surface of condenser plates.

The view proposed, which considers metallic and electrolytic conduction as identical, finds strong support in the following investigations.

Prof. J. J. Thomson finds, as the result of experiments, "that the velocity of propagation of a rapidly alternating current along an electrolyte surrounded by air cannot differ much from the rate along a wire;" and in examining the resistance of electrolytic alternating currents, "the results obtained agree sufficiently well to enable us to say that the relative resistance of electrolytes is the same when a current is alternating a hundred million times a second as for a steady current."

Prof. Mengarini, of Rome, in a very exhaustive paper on electrolysis by alternating currents, formulates the following law:—(4) "A limiting value to the rapidity of alternations exists, beyond which decomposition does not take place;" which he proves both theoretically and experimentally; and he finds that at the limit "the voltmeter only becomes heated by the passage of the current like an ordinary metallic conductor." He also states in his conclusions (6): "A voltmeter traversed by an alternating current behaves like a metallic conductor possessing self-induction."

A committee appointed by the British Association has also investigated a series of solid compounds, such as sulphides and selenides, some of which conduct purely metallically, others purely electrolytically, and others in both ways at the same time, and declared themselves unable to draw any marked line of distinction between these bodies.

To resume. The number of the molecular chains formed will depend on the strength of the electric field and on the concentration of the electrolyte, whilst the cross-sectional area of each zone of decomposition will depend on the strength of the current and number of chains, and the current density will be measured by the number of such chains in the cross-section of the electrolyte.

The existence of these zones explains:—

I.—How the atoms can travel along molecular chains towards their respective electrodes without recombination.

II.—Why the atoms are given off as molecules at the electrodes only, because there the electric field being weakest, and atoms of one kind preponderating, they combine and are given off.

By artificially weakening the electric field by introducing a metallic plate into the path of the molecular chains, such plate acts similar to an electrode. Mr. A. Tribe, by interposing silver plates in a copper sulphate cell, obtained one end coated with copper, the other with protoxide of silver, and found the boundary line of the zone of deposition to be at right angles to the line of flow of the current. This enabled him to observe the refraction of this line of flow by interposing a porous vessel with water, whose parallel sides were in-

clined at an angle of 45° to the sides of the rectangular electrolytic trough, a most important verification of the directive tendency of the current in an electrolyte.

Prof. J. J. Thomson has also shown that an electric field is weakened in the presence of a solid dielectric, because the surface tension is increased. Hence, if a solid dielectric is intruded into a zone of intense electric action, by sending the current through a porous diaphragm or a cracked glass plate, the fields will be weakened and atoms liberated, as abundantly proved by the experiments of Grothuss, F. Braun, Ostwald, Tamman, Overbeck, and others.

III.—Why the atoms cannot escape through out of the liquid is explained by the directive force preventing the atoms escaping laterally out of the decomposing zones.

It is obvious that only an exceedingly small electromotive force would be required to produce the minimum zone of decomposition necessary for electrolysis along a single or few molecular chains; and, since a weak electric field could only have a few lines of force, there would only be a few such rows, and this gives us an explanation for the electrolysis produced by the infinitesimal currents observed by Helmholtz, M. Depretz, and others.

Also, if two bad conductors of slightly varying conductivity be mixed, such as alcohol and water, the conditions are provided for electrolytic action, the better conducting forming the guiding conductors, the other dielectric tubes, whence a greatly increased conducting power is produced and observed; as witness the experiments of Gladstone and Tribe, Overbeck, Pouillet, Ayrton and Perry, and others.

This also explains the action of exceedingly minute quantities of impurities on influencing the conductivity of electrolytes.

The assumption that the solvent is primarily decomposed suffices to explain all the chemical phenomena observed in electrolytic cells, and was fully accepted by the older electricians, being specially worked out by Berzelius and his school.

The electrolysis of solutions by strong currents give strong support to this view; for when constituents of the solvents are more rapidly generated than they can be absorbed by secondary chemical action, they are given off in the free state. I have shown this to be the case for copper sulphate solutions, from which I have obtained oxygen and hydrogen by sufficiently increasing the strength of the current. Kohlrausch also states that in very dilute solutions water is decomposed.

The complicated phenomena classed under polarisation are mainly due to voltaic currents arising from chemical changes taking place at the electrodes and their physical effects.

The phenomenon known as wandering of the ions has been shown by Profs. Wiedemann and Quincke to be due to three causes.

I.—The free charges on the surface of the molecular chains, producing motion in opposite directions of the salt and the solvent molecules.

II.—The same effect being also produced by the free charges on the electrodes; and

III.—By the electrification of the vessel containing the electrolyte, which latter they also consider to explain the phenomena known as electrical endosmose.

It is obvious that these explanations may also be adopted in connection with the above expressed views.

In order to corroborate the theory of molecular chains I have carried out a series of experiments with different apparatus, to study whether the displacement of the molecular conductors would influence the conductivity, I found that the resistance of a jet of electrolyte, which was caused to flow at various speeds between the electrodes rose proportional to the velocity of the electrolyte up to a maximum of about ten per cent. of the total deflection. In order to ensure the result being solely due to the velocity of the jet and not to diminution of the area of the conductor, the electrodes carefully insulated except at the places where the jets one to each electrode impinged, were kept immersed in separate cells connected with a tube and provided with overflow tubes, the jet playing beneath the surface of the electrolyte, the result was in complete accordance with those previously obtained.

Faraday has shown that an interrupted current flowing through an electro-magnet is able to induce a current in a secondary coil made of an India-rubber tube filled with an electrolyte wound round the keeper.

Considering it to be of interest to have both a primary and secondary coil of electrolytic conductor, I constructed two flat spirals of India-rubber tubing filled with acidulated copper sulphate, and provided with copper electrodes; for the primary, a continuous current of 90 volts was employed, which was simply interrupted by means of an electric bell worked from an independent battery.

The secondary coil was connected with a Sir Wm. Thomson 60 ohm reflecting galvanometer; a thermo current giving 10 divisions was observed, but the effect of the induced alternating current was to produce intermittently deflections of over 50 divisions on each side of the zero, thus removing all doubt of the success of the experiment.

The complete analogy between an electrolyte and a high resistance wire led me to suspect that if such a wire were inserted between the electrodes electrolysis would be observed at the ends. On referring to the literature I found that Jacobi had obtained the desired result with a German silver wire in a copper sulphate solution, but did not obtain the result with platinum. Having some thin platinum wire at hand I determined to repeat the experiment, coiling the wire to increase its resistance. Copper was deposited along about one half of it, beginning slowly at the negative electrode whilst the other half turned black by oxidation, and was gradually destroyed at the end nearest the positive electrode.

I know that the view I have ventured to bring before you leaves many facts connected with electrolysis, as yet unexplained, but the same must be admitted for all other theories on the subject hitherto

propounded, over which this view has, I believe, the advantage that it brings the propagation of electric energy along electrolytes into harmony with the now generally accepted theory of Clerk Maxwell of the propagation along metallic conductors, and that it offers an explanation of the electrical as well of the chemical phenomena observed.

REVIEWS.

An Introduction to the Mathematical Theory of Electricity and Magnetism. By W. T. A. EMTAGE, M.A., Examiner in the School of Natural Science, Oxford. Oxford: at the Clarendon Press.

It is rather difficult to see why this book has been written, although the author states that its object is to supply an introduction to the mathematical treatment of electricity and magnetism. The work can hardly be said to give information which many other works do not give, although no doubt the subjects treated of are dealt with in a somewhat different way to that in which they are considered elsewhere. The practice of ringing the changes so often is becoming a somewhat monotonous one, though it is seldom that something novel and useful does not turn up in the process. A feature in the book before us is, that it is complete in itself, and may be read without previous knowledge of the subject; this appears to be literally correct, which is by no means always the case in books of the kind. To generally sum up, the production may be regarded as a very condensed edition of Clerk Maxwell, and Mascart and Joubert's, works; it will no doubt be appreciated by many students.

Primary Batteries. By HENRY S. CARHART, A.M., Professor of Physics in the University of Michigan. Boston: Allyn and Bacon. London: ELECTRICAL REVIEW office.

The author of this book is well known as a careful and practical writer, and these qualities are well borne out in the small volume before us. A great deal has been written about primary batteries, but chiefly in detached portions; the interest in the subject now, however, fairly calls for compilations entirely devoted to the same. The batteries mentioned are almost wholly of the practical type, those which are merely curiosities being excluded. The sections dealing with the amalgamation of zinc are very good, and give information which is by no means generally known. The batteries described are practically divided into three important groups, viz., "open circuit," "closed circuit," and "standards." A miscellaneous group is added. The proper method of testing batteries is well explained, several curves of the rendering being given; in fact, the chapter on this subject is one of the most useful in the book. Altogether, we can recommend the whole work as being really "first rate," and well worth being kept up to date by the issue of fresh editions.

A Manual of Practical Electro-Therapeutics. By ARTHUR HARRIES, M.D., and H. NEWMAN LAWRENCE. London: Sampson Low, Marston & Co., Fetter Lane.

If the public who interest themselves in the subject of electro-therapeutics would purchase works of this description instead of the rubbish published by quacks who shall be nameless, they would greatly benefit themselves and others also. The only real fault we have to find with the work is the exceeding coarseness of the illustrations, which are mere reproductions of badly-executed sketches.

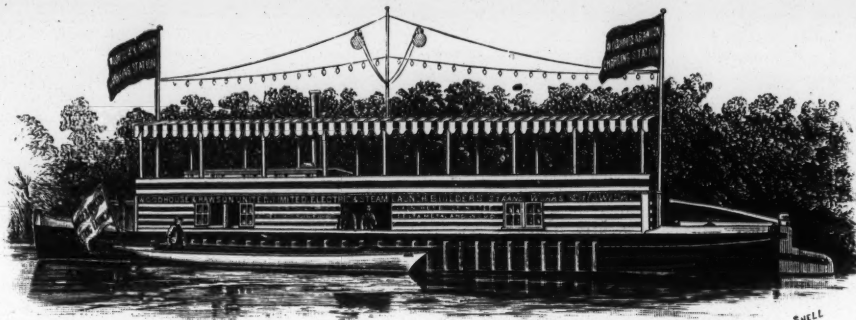
WOODHOUSE AND RAWSON'S FLOATING CHARGING STATION.

THE number of electric launches upon the upper reaches of our pretty river is constantly on the increase, and Messrs. Woodhouse and Rawson United, Limited, have devoted much attention to the development of this branch of electrical enterprise.

Besides building a number of these launches, they have established charging stations at Kew, Chertsey, Windsor, and

Abingdon, and have recently equipped a floating charging station for attendance at the ever-popular river regattas.

In appearance very similar to a house boat, the charging station consists of a river barge 80 feet long and 14 feet beam. The machinery is placed in a compartment at one end, and consists of a semi-portable steam engine plant and dynamo of sufficient output to charge the accumulators on six launches simultaneously.



The remaining portion of the boat contains a store room, an office, sleeping apartments for the attendants, and an engineer's room, where a lathe is fixed, and attendants are kept constantly in readiness to effect any repairs to launches which may be required; a convenience boat owners know how to appreciate.

The charging station also fulfils the duty of supplying any current which may be required for illuminating with the electric light the numerous house-boats on the river, and at the late Henley Regatta, it partly illuminated the course with an arc light.

NOTES.

Bodmin Electric Lighting.—The Bodmin Town Council have invited tenders from the gas company and certain other firms for lighting the town by electricity.

The Electric Light in Rome.—The streets of Rome will be lighted by electricity at the end of the present year. The motor power will be transmitted by electric wire from Tivoli, a town about 30 kilometres from Rome. The Via Nazionale will be the first street to which the electric light will be applied in the city of the Seven Hills.

Proposed Electric Lighting of St. Helen's Town Hall.—At the monthly meeting of the St. Helen's Town Hall Committee, a report on the ventilation and lighting of the Town Hall by electricity was read. The estimate was between £1,300 and £1,400, and it was stated that electric lighting would be a saving in expenditure. It was agreed to call a special meeting to consider the matter.

The Electric Light at Brighton.—The lighting committee reported to a meeting of the Brighton Town Council held last week, that Mr. Shoolbred had informed them that the works at the electricity generating station were so far advanced, that the corporation would be in a position to supply electricity to the public at a date not later than September 15th next. The committee recommended that the offer of Messrs. Sharp and Kent to wire and fit up lamps at the station for the sum of £204 15s. be accepted, and eventually, the committee's recommendation was adopted.

Ipswich Lighting.—At a recent meeting of the Ipswich Paving and Lighting Committee, Messrs. R. D. and J. B. Fraser offered to erect at their own expense two electric arc lamps and brackets on their premises, one at the Princes Street corner, and the other at the Elm Street corner, each to cost £30; also to provide the electricity, the necessary carbons and attendance, and to keep the lamps alight during the same hours as other public lamps in the town, if the committee would pay them the sum of £15 per annum. The offer was accepted.

Accumulator Traction in Lyons.—The Lyons Tramway Company, after making experiments with nearly all systems of locomotion, has now entered upon a series of trials with an accumulator car. The car carries 112 cells weighing $2\frac{1}{2}$ tons, and its total weight when fully loaded is 11 tons. The results obtained with this car have been satisfactory, and the directors of the company seem disposed to introduce other electric tramcars.

Electric Lighting in East London.—The Whitechapel District Board is going to apply for a provisional order for the lighting of a portion of the district by electricity.

Electric Lighting at a Fancy Fair.—We understand Mr. Storr, of Westgate-on-sea, temporarily lighted the various stalls and rooms at the "Charles Dickens" fancy fair held on Wednesday and Thursday last in connection with Christ Church. The lighting was highly appreciated by the stall holders and visitors.

New Electrical Text Book.—There is to be published in September, a first book of electricity and magnetism for the use of elementary science and art and engineering students. It was designed primarily as an introduction to existing so-called elementary text-books; but will be found by teachers to cover the elementary syllabus of the Science and Art Department.

Helstone Town Council and Electric Light.—The Helstone Town Council have decided to have electricity for the town lighting, but are intending in the interval which must elapse before the electric light can be instituted to have the lamps lit by oil instead of gas. The *Western Morning News* states the reason of this action to be that the majority of the members of the Council are at loggerheads with the gas company.

Glasgow Electric Lighting.—The Corporation of Glasgow have, as before announced, decided to appoint an electrical engineer as a permanent official of the city. Commenting upon this matter, the *Glasgow Evening News* says that the circumstance that a commencing salary of only £250 a year is offered signifies that electric lighting as yet occupies a small place in the estimation of the Corporation. It is not very clear what degree of responsibility is intended to attach to the electrical engineer of Glasgow.

Catalogue.—The Key's Electric Company has just issued its new catalogue, which is, in many respects, quite unique. It is made up of a number of leaflets, each of which treats of a special subject, and the whole collection is a fair representation of all the various details relating to electric light, motive power, heating, and instruments. That part which treats of instruments for physical laboratories is sure to interest professors and science teachers in general. We were particularly struck with the very complete description of apparatus for theatre lighting, the best of the kind we have ever seen. It contains the simplest as well as the most elaborate switchboards, and every requisite for effective stage lighting. Voluminous catalogues made up of detachable leaves have their advantages, inasmuch as many people require only those portions which relate to their own specialities. We congratulate the Keys Electric Company upon this practical and useful publication.

150 C.P. Arc Lamp.—An arc lamp to give as little as 150 C.P., is shortly to be introduced.

Kingstown Lighting.—The Kingstown Town Commissioners have agreed to advertise for tenders for lighting the town for one or three years by electric light or gas.

Austin and Myers.—This firm is circulating a new list of prices of the "Infant" and "Novel" dynamos, and of continuous current transformers, dated August, 1891.

New Firm.—Messrs. Hughes and Claude W. Hill, both of whom have been connected more or less with Messrs. Mather and Platt, have just started business as consulting electrical engineers at 5, Parsonage, Manchester.

To Makers of Miners' Lamps.—Mr. H. M. Morrison, of Cleveland, Ohio, in a letter addressed to the *Colliery Guardian*, asks whether anyone can recommend "a good practical electric lamp for mining purposes; dry battery, not to exceed in weight twice the weight of the ordinary Clanny, and to produce a good clear, steady light."

Electric Cranes.—Southampton shipowners and merchants are anticipating with great interest the intended introduction of electric cranes on the town quay, the Harbour Commissioners having made arrangements with the local electric supply company for that purpose. Tenders are now being called for certain works for the purpose of strengthening the structure upon which the cranes are to be placed.

Electric Welding in the Repairing of Ironwork.—The recent catastrophe at Moenchenstein called attention to Riess's process for rapidly repairing ironwork by electric welding. The *Revue Industrielle*, devotes some considerable space to showing how admirably this process works when applied to the repairing of various iron structures, rails &c., that have become damaged by accident, and which, owing to the circumstances of such cases, required to be very rapidly repaired because of the traffic.

An Electric Ventilator.—*L'Electricité*, notices a curious electric ventilator for supplying a building with fresh air, either cold or warmed, as desired. An electric motor sets the ventilator revolving, and the revolution sucks cool air in. When warm air is desired, a current is sent into a network of fine wire possessing a high resistance, and through the network the air is obliged to pass: the current heats the wires and the air necessarily becomes heated. The movement of a commutator, is sufficient to change the character of the air supplied by the ventilator. This system is capable of considerable adaptation, and it is stated that the hygienic results are uniformly good.

The Electrical Accessories Company.—This company has recently been reconstructed, and their London office removed from 66, Victoria Street, S.W., to more central and convenient premises at 5, Macclesfield Street, Shaftesbury Avenue (near Piccadilly Circus). The company are also increasing their works in Birmingham, and have fitted them with additional labour-saving tools and improved appliances, enabling them to execute any special work at short notice. Small repairs and alterations can in future be done in London, but the bulk of the work and all large orders will continue to be executed at the Birmingham factory. Messrs. Drake and Gorham have ceased their connection with the company.

Co-operative Electricity.—In the South Wales *Daily News* of August 24th, there appeared the following advertisement:—"Electricity.—Wanted immediately, thoroughly experienced person, with practical knowledge of electric lighting, to take charge of engine, boiler, and dynamo, do own repairs, and fill spare time in grocery store-room; permanency for good man.—Apply, enclosing copies of testimonials, stating salary and experience, Co-operative, Abertillery." Here is a good chance for any young electrician who can satisfy the advertiser that his knowledge of grocery is equalled by ability in the profession of his choice. We would suggest, in view of the tendency of the times, that the City and Guilds of London Institute, the Finsbury Technical College, and other educational establishments, should take the hint.

Theatre Lighting in Bucharest.—The new theatre in Bucharest, in Roumania, has been fitted up with the electric light.

Electric Lighting at a Newcastle Club.—The Union Club, Newcastle, is to be lighted by electricity. It is proposed to light the main hall, the dining, morning, billiard, private dining, smoke, card, and reading rooms, including also the kitchens and sculleries.

Proposed New Electric Tramways in Rome.—Captain Cattori, who represents the electric tramway from the Piazza del Popolo to the Ponte Molle in Rome, has asked for a concession for the installation and working of four new electric tramways in that city.

Safety Mining Cable.—To obviate the risk attending the breakage of cable in mines, caused by falling roofs or derailed tubs, Messrs. Goolden & Co. are about to introduce, under the name of the "safety mining cable," a cable that can be torn asunder without spark, arc, or flame.

The City of London Electric Lighting Company, Limited.—The Board of Trade has given its final consent to the transfer to this company of the provisional orders granted to the Brush Electrical Engineering Company, Limited, and the Laing, Wharton and Down Construction Syndicate, Limited.

The Offenbach-Frankfort Power Transmission.—On the 21st inst. the installation for the transmission of power from Offenbach to the Frankfort Exhibition was set in operation and worked efficiently. The overhead conductors have been put up by the Imperial postal authorities. The system used is the Haselwander rotary current method.

Telephoned Telegrams in Belgium.—The Belgian Telegraph authorities, have just issued a report of the number of telegrams exchanged by telephone between the subscribers to the telephone lines and the telegraph offices during the month of July. This report shows 70,615 transmissions, and a large increase is shown over former months.

Tramway Companies and Electricity.—Replying to a contemporary, which recently stated that various tramway companies had abandoned the idea of working their cars by electricity, Mr. Thomas Smith, of the General Electric Power and Traction Company, writes to explain that "The action of local authorities is the sole cause of the slow development of electric traction in this country."

Chicago Exhibition.—The electricity building at the Chicago World's Fair, on which work has been started and is going on rapidly, will be completed about December 1st, 1891. The demand for space now aggregates something over 200,000 square feet, and in addition to this there have been received numerous preliminary applications not defining exactly the amount of space required.

Portraits.—A contemporary on this side states that the New York *Electrical World* of August 8th contains a speaking likeness of Mr. Mordey. The features of this gentleman are certainly well reproduced, but the tone of the picture gives the impression that the original is a "cullud pusson" instead of a fair Englishman. But Mr. Mordey's work is so varied in its nature that perhaps his complexion is also "chameleon like" in its changes.

The Improved Bernardos Electric Welding Process.—Messrs. Lloyd & Lloyd are enlarging their installation of this process which they have successfully applied to the manufacture of iron and steel tubes and fittings. A very extensive series of some hundreds of tests has been made by Messrs. David Kirkaldy & Son of bars of various brands of iron and steel in order to test the nature of the welds. The results obtained show that a fibrous fracture can be relied upon at the weld with iron, and a silky fracture with steel, and that the contraction of area at fracture and extension, as well as the ratio of weld to solid, are all maintained at high average figures. Messrs. Lloyd & Lloyd, as soon as the holiday season is over, intend to invite a number of the leading engineers to inspect the process at their works.

Killed by Electricity.—A New York telegram, dated the 23rd inst. states, that while a workman employed by an electric light company was attempting to repair some lights on the Casino at Coney island, on Saturday night, he seized two wires and was instantly killed. The body swung in the air, the hands rigidly grasping the wires. An immense crowd gathered in the vicinity, and, finally, the current being turned off, the body dropped to the ground.

British Association.—At a meeting of the General Committee on Monday last Sir Archibald Geikie, LL.D., and Director-General of the Geological Survey, was unanimously elected president of the British Association for the 1892 meeting at Edinburgh. It was decided by a large majority that the meeting should commence on August 3rd, that being—all things considered—the most suitable time available. It was also proposed and carried unanimously that Nottingham should be the rendezvous for 1893.

The Weymersch Battery.—During the past few months the Weymersch syndicate has made considerable improvement in the design of its battery and the method of its application to various technical purposes. It is proposed to give an exhibition of the capabilities of the battery to-day, and on Tuesday next, at 2, Victoria Mansions, Westminster, when the battery may be seen charging accumulators, running a 24-inch Blackman fan, and working a Merryweather pump of 12 gallons a minute capacity.

Electrical Communication at Stafford Asylum.—Messrs. William A. Shaw & Co., of Stockport, have completed the contract for improved electrical communication at the Stafford County Asylum, the installation consisting of 13 fire alarm pulls, each pull ringing 11 alarm bells, and indicating the fire on six different indicators; also bells summoning the fire brigade individually, and bells from the night wards to nurses' and attendants' bedrooms. There is also a complete telephone system arranged for intercommunication between the officials, and one of Gent & Co.'s patent ink-marking watchman's clocks registering from 18 positions. The wire is of No. 16 gauge throughout, and upwards of 12 miles of wire has been used in the work.

Frankfort Electrical Exhibition.—Frankfort-on-the-Main, August 21st.—"This morning all the wires transmitting the electric current from the Falls on the Neckar, at Lauffen, to the Central Hall at the Electrical Exhibition here were connected up, and the current was switched on to set the machinery in motion. The experiment passed off without a hitch, and the apparatus works perfectly. The transmitters used are those of Lahmeyer, whereby both constant and intermittent currents are conveyed. In view of the immense strength of the electric energy passing through the cable between here and Lauffen, the most extraordinary precautions have had to be taken to prevent injury to life or limb. As the current is conveyed by the roadside along the telegraph line, notice boards in the shape of death's heads have been fixed to each pole with the words 'Do not touch!' Warnings have also been generally issued pointing out the danger of fastening any animal or vehicle to the poles, or bringing them within dangerous proximity of the apparatus. Schoolmasters have been requested to warn the children not to approach the lines or fly kites near the wires."

A later telegram, dated August 25th, gives the following more accurate information:—"At noon to-day the electric lamps in the exhibition here were lighted for the first time by the current transmitted from the generating centre at the Lauffen Falls of the Neckar, over 100 miles distant from this city. Yesterday the various authorities of Wurtemberg, Baden, Hesse, and Prussia, through whose territory the cable passes, formally took over the undertaking, and subsequently made it over to the General Electricity Company of Berlin and to the Oerlikon Machine Works of Switzerland, the constructors of the plant and electrical appliances. At eight o'clock in the evening the electrical current was transmitted from Lauffen along the cable, and it was found that the precautionary measures adopted along the cable line to insure the safe transmission of the electric current were faultless. The transmission of the electrical current derived from water power over a distance of 108 miles is, therefore, an accomplished fact.

Electric Lighting in Altona.—The railway station at Wilhelmsburg is to be lighted by electricity. The work is being carried out by the Helios Company, of Cologne-Ehrenfeld.

The Siam Electric Light Company.—Wires have already been laid down by the Siam Electric Light Company in Bangkok, and it is reported that the arrangements for lighting will shortly be completed.

South Shields and Electric Lighting.—The Corporation is inviting proposals from electric lighting companies and others for the laying down, manufacture, supply, and working of the electric light in the county borough of South Shields. Proposals to be sent to the town clerk.

Electric Lighting in Southport.—The new opera house in the Winter Gardens is expected to be opened next month. The electric lighting installation, which is being carried out by the Manchester Edison-Swan Company, is now well in hand.

Ozokerite.—The principal ozokerite mines are situated in Galicia, the produce being about 200 tons per week. It is estimated that about half this quantity goes to Russia, where it is used in the manufacture of ceresine candles for churches. One of the largest firms of mine proprietors and exporters is that of Messrs. L. N. Grunbaum and Son, who dispose of from 50 to 60 tons per week. The London office of this firm is at 84, Leadenhall Street.

Fire Brigade Communication—Leyton Local Board.—The special committee on this subject reported that they had considered estimates and rates from the Post Office authorities, the National Telephone Company, and the Universal Telephone Company, and recommended that the estimate of the Universal Telephone Company be accepted by the board, viz.: Four telephone circuits, approximate cost, £125; firemen call bells for 26 stations, averaging 110 yards, independent circuits with special loud bells, say £68; the company to undertake the maintenance for £12 10s. per annum. Dr. Turner suggested the erection of push bells at each of the fire stations, so that any one discovering a fire could go there and call the brigade. At present they would have to go to the house of one of the members. The report was adopted, with this addition.

The Electro-Harmonic Society.—The meetings for the season 1891-92 have been fixed for the following Friday evenings:—October 2nd, November 6th, November 27th (ladies' night), February 5th, March 4th (ladies' night), and, ominous date, April 1st. Gentlemen desirous of introducing friends as new members should apply without delay to the hon. secretary. The subscribers to the Society may be interested to learn that on Wednesday evening next, at the Birkbeck Literary and Scientific Institution, Mr. T. E. Gatehouse, one of the musical directors, assisted by his colleague Mr. Alfred Izard, will give a violin recital, the programme including Beethoven's "Kreutzer" sonata, "Romance in F," Vieuxtemps's "Ballade and Polonaise," a *pot-pourri* on "Scotch Melodies," and other items. Part songs will also be performed by Mr. Clement Colman's choir boys.

The Electric Welding Company, Limited.—We notice the issue of the prospectus of this company, which we have perused with some astonishment. The patents, we think, can in no way be considered controlling patents for electric welding, similar methods having been used for a long time past. The wisdom of giving, therefore, £212,000 for them (£83,330 in shares and the rest, we presume, in cash, if available) is not very apparent. The quality of the welds is doubtless as described by the distinguished experts whose opinions are given, but the price for the patents is ridiculously high. We notice that from some of the newspaper advertisements the purchase price is omitted (a very serious omission), and that on the face of these advertisements it would appear that the £83,330 (in shares) is all that is to be paid to the vendors. This last sum many may consider more than enough, but the higher figure (£212,000) is, from an investor's standpoint, simply absurd.

An Electric Tramway in Guernsey.—Messrs. Siemens Brothers are erecting an electric tramway in Guernsey, the length of which is about 4 kilometres.

Cost of St. Pancras Electric Light Staff.—Prof. Henry Robinson, the engineer employed by the St. Pancras Vestry to carry out the installation of the electric light in this parish, has estimated the cost of the staff as follows:—Engineers, assistants, and clerks, £1,100; engine drivers, stokers, &c., £1,500; total annual cost, £2,600. The Electricity Committee propose for the present to keep the total under £2,000. In the event of its becoming necessary to expend more than £2,000 a year in the total they will report to the vestry, and only act upon the instruction of that body.

The Growth of Electric Lighting.—Regarding the relative positions of England and America in the matter of electric lighting, Mr. W. H. Massey, writing to the *Times*, states that when in the United States last winter he found, much to his surprise, that we then had in London alone more incandescent lamps than could be heard of in five of their largest cities (including New York) all put together. It is well known that the incandescent lamp industry in some American cities is secondary in importance to that of arc lights, but Mr. Massey carefully avoids reference to this fact in comparing the positions.

Copper Tubes by Electrolysis.—Mr. Alexander Watt informs us that he has discovered a process, for which he has applied for a patent, for producing copper tubes by electrolysis, which is entirely free from the objections urged against the Elmore process. It is stated that by the new process the copper will be deposited at a considerably less cost, and with much more certainty and uniformity than is obtainable by the other method referred to; while at the same time lamination and exfoliation of the metal are absolutely impossible; consequently the durability of the tubes will be assured, while the tensile strength of the deposited metal will be increased. We hope shortly to hear more of Mr. Watt's tube process, which, if it proves to be as good as he anticipates, will be hailed with much interest.

Obituary.—There were only two men amongst the members of the Commune in Paris, in 1871, who dropped politics to devote their time to electricity. Antoine Arnaud, who some 12 years ago took proceedings against Edison for alleged infringements, and who died in Paris in 1884, was one of them. The other, Auguste Serrailier, who was secretary of the "Internationale" in London, and who during the Commune was for some time Minister of Public Works, died suddenly of heart disease, on Friday last, at Messrs. Martin, Ducamp & Co.'s works, Joinville le Pont, near Paris. He was the inventor of a very ingenious electric arc lamp, some primary batteries, and other electric apparatus.

Death of the Postmaster-General.—We regret to announce the death of Mr. H. C. Raikes, M.P., which has happened at an age, when most of our statesmen are in the midst of their political career. It is unnecessary for us to comment upon the attitude which Mr. Raikes adopted towards the Post Office employés generally, as this has been repeatedly referred to in the columns of the *ELECTRICAL REVIEW* within the past year. A meeting of the sorters employed at the General Post Office was held on Wednesday, and a vote of condolence with the widow and family of the late Postmaster-General was passed. The desirability of establishing a lasting form of memorial was declared, and a deputation appointed to convey to the place of interment a floral tribute subscribed for by the Post Office employés.

NEW COMPANIES REGISTERED.

Martiny, Limited.—Capital £200,000 in £4 shares. Objects: To acquire and take over upon the terms of an unregistered agreement, dated July 2nd, 1891, between the New Asbestos Company, Limited, of the one part, and J. Simpson (for this company) of the other part, the business of the New Asbestos Company, Limited. To acquire the

business of Messrs. Marting & Co., India-rubber, gutta-percha and cable manufacturers and merchants, upon the terms of a similar agreement. To carry on the undertakings and businesses carried on by the above concerns. To manufacture telegraph wires, cables and wires generally. Signatories (with one share each): W. C. H. Lupton, 60, Hargrove Street, Clapham; T. R. Watts, 86, Ridge Road, Hornsey; F. A. Koszelski, 14, Pelham Road, Wimbledon; T. Lattimer, 119, Drummond Road, S.E.; W. McDonell, 40, Lacar Road, East Dulwich; C. Lloyd, 60, Gresham Street, E.C.; A. Smith, Whitton, near Hounslow. The number of directors is not to be less than three nor more than seven, the first to be appointed by the subscribers. Qualification £1,000. Remuneration £900 per annum, with an additional £100 for the chairman and a percentage of the profits. Registered on the 20th inst. by Michael Abrahams, Sons & Co., 8, Old Jewry, London, E.C.

Oxford Electric Company, Limited.—Capital £100,000 in £5 shares. Objects: To carry on in the city of Oxford and elsewhere the business of an electric lighting company in all its branches; to undertake the lighting of streets and other places and buildings public and private; to enter into and carry into effect an agreement with the Electric Construction Corporation, Limited; to manufacture, sell, deal in, and let on hire, engines, machinery, wires, lamps, instruments, and apparatus necessary for the production, supply, storage, measurement, use, application, or distribution of electricity. Signatories (with 1 share each): J. J. Courtenay, Trinity College, Oxford; H. Musgrave, Seymour Villa, Anerley, S.E.; G. Offor, 4, Great Winchester Street, E.C.; J. Ebbsmith, 86, St. James's Street, S.W.; R. Buckell, 32, Beaumont Street, Oxford (Mayor); T. Lucas, Northlands Oxford (Sheriff); T. Green, 25, Lackford Road, Oxford (Alderman). The number of directors is not to be less than three nor more than seven, the first to be appointed by the subscribers. Qualification £250. Remuneration to be fixed at the general meeting. Registered on the 24th inst. by W. Webb & Co., 23, Queen Victoria Street, E.C.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Municipal Electric Light and Power Corporation, Limited.—The annual return of this company, made up to the 31st of December, 1890, was filed on the 18th inst. The nominal capital is £25,000 divided into 2,490 ordinary shares of £10 each, and 100 founders' of £1 each, 37 ordinary, and 30 founders' have been taken up, and upon the former the full amount has been called, while the latter are considered as paid. The calls paid amount to £210 and unpaid to £160.

The annual return made up to the 14th inst. was also filed on the 18th inst. The same number of shares are taken up and all the calls are paid. Office, 33, Old Broad Street, E.C.

Energy Gas Electric Lighting and Power Company, Limited.—The registered office of this company is situate at 5, Chancery Lane, W.C.

British Electro-Chemical Agency, Limited.—The registered office of this company is situate at Worcester House, Walbrook, E.C.

The London Platino-Brazilian Telegraph Company, Limited.—The London Platino-Brazilian Telegraph Company, Limited, announce that the half-yearly coupon on the 6 per cent debentures due on September 1st, will be paid at the banking house of Messrs. Glyn, Mills and Company, Lombard Street, E.C.

Electric Installation and Maintenance Company, Limited.—Letters of allotment in the Electric Installation and Maintenance Company, Limited, have been posted.

TRAFFIC RECEIPTS.

The Brazilian Submarine Telegraph Company, Limited. The receipts for the past week amounted to £4,188.

The City and South London Railway Company. Traffic receipts for the past week amounted to £728.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending August 21st, 1891, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Company were £2,812.

SHARE LIST OF ELECTRICAL COMPANIES.

Present Amount Issued.	Name.	Stock or Share.	Closing Quotation. (August 20.)	Closing Quotation. (August 27th.)	Business done during week ending August 27th, 1891.
					Highest. Lowest.
250,000/	African Direct Telegraph, Ltd., 4 p. c., Deb. Regd. and to Bearer	100	93 — 102	99 — 102	99 1/2 99 1/2
1,300,980/	Anglo-American Telegraph, Limited	Stock	46 1/2 — 47 1/2	47 — 48	47 1/2 47 1/2
2,849,510/	Do. do. 6 p. c. Preferred	Stock	85 — 86	86 — 87	86 1/2 86 1/2
2,849,510/	Do. do. Deferred	Stock	10 — 11	11 1/2 — 12 1/2	12 1/2 10 1/2
130,000	Brazilian Submarine Telegraph, Limited	10	11 1/2 — 12 1/2	11 1/2 — 12 1/2	12 1/2 11 1/2
53,200/	Do. do. 5 p. c. Bonds	100	99 — 102	99 — 102	...
75,000/	Do. do. 5 p. c., 2nd Series, repayable in June, 1906	100	103 — 107	103 — 107	...
77,978/	Brush Electrical Engineering Ordinary, Nos. 1 to 63,416	3	2 1/2 — 2 1/2	2 1/2 — 2 1/2	...
69,996/	Do. do. Non cum. 6 p. c. Preference, Nos. 1 to 63,416	2	1 1/2 — 2	1 1/2 — 2	...
50,000	City and South London Railway, Nos. 1 to 50,000	10	3 — 5	3 — 5	...
\$7,716,000	Commercial Cable, Capital Stock	\$100	105 — 109	107 — 109	108 1/2 108 1/2
224,850	Consolidated Telephone Construction and Maintenance, Limited	14/-	8 — 1 1/2	8 — 1 1/2	...
20,000	Crompton & Co., Ltd, 7 p. c. Preference Shares, Nos. 1 to 20,000	Stock	4 — 5	4 — 5	...
16,000	Cuba Telegraph, Limited	10	10 — 11 xd	10 — 11	10 1/2 10 1/2
6,000	Do. do. 10 p. c. Preference	10	16 1/2 — 17 1/2 xd	16 1/2 — 17 1/2	...
12,931	Direct Spanish Telegraph, Limited, ... (£4 only paid)	5	3 1/2 — 4 1/2	3 1/2 — 4 1/2	3 1/2 3 1/2
6,000	Do. do. 10 p. c. Preference	5	9 1/2 — 10 1/2	9 1/2 — 10 1/2	...
60,710	Direct United States Cable, Limited, 1877	20	10 1/2 — 11	10 1/2 — 11	11 10 1/2
400,000	Eastern Telegraph, Limited, Nos. 1 to 400,000	10	14 1/2 — 14 1/2	14 1/2 — 14 1/2	14 1/2 14 1/2
70,000	Do. do. 6 p. c. Preference	10	15 — 15 1/2	15 — 15 1/2	15 1/2 15
200,000/	Do. do. 5 p. c. Debs. (1879 issue), repay. August, 1899	100	107 — 110	107 — 110	...
1,200,000/	Do. do. 4 p. c. Mortgage Debenture Stock	Stock	107 — 110	107 — 110	108 1/2 108 1/2
250,000	Eastern Extension, Australasia and China Telegraph, Limited	10	14 1/2 — 14 1/2	14 1/2 — 15 1/2	15 14 1/2
78,300/	Do. do. 5 p. c. (Aus. Gov. Sub.), Deb., 1900, red. ann. drgs. reg. 1 to 1,049, 3,976 to 4,326	100	103 — 106	104 — 107	...
276,200/	Do. do. Bearer Nos. 1050—3,975 and 4,327—6,400	100	103 — 106	104 — 107	...
320,000/	Do. do. 4 p. c. Debenture Stock	Stock	105 — 108	105 — 108	107 106 1/2
135,000/	Eastern and South African Telegraph, Ltd., 5 p. c. Mort. Deb. 1900 redeem. ann. drawings, Registered Nos. 1 to 2,343	100	102 — 105	102 — 105	...
180,400/	Do. do. do. to bearer, Nos. 2,344 to 5,500	...	102 — 105	102 — 105	...
201,600/	Do. do. 4 p. c. Mort. Debs. Nos. 1 to 2016, red. 1909	100	98 — 101	98 — 101	100 1/2 100 1/2
45,000	Electric Construction, Limited, Nos. 101 to 45,100	10	3 1/2 — 4 1/2	3 1/2 — 4 1/2	...
19,900	*Electricity Supply Co. of Spain, Nos. 101 to 20,000	5	4 1/2 — 5	4 1/2 — 5	...
66,750	Elmore's French Patent Copper Depositing Co., Ltd, Nos. 1 to 66,750	2	2 1/2 — 2 1/2	2 1/2 — 2 1/2	2 1/2 2 1/2
70,000	Elmore's Patent Copper Depositing, Limited, Nos. 1 to 70,000	2	3 1/2 — 3 1/2	3 1/2 — 3 1/2	3 1/2 3 1/2
67,385	Elmore's Wire Mfg., Ltd., Nos. 1 to 67,385, issued at 1 p.m., all pd.	2	1 1/2 — 2	1 1/2 — 2	1 1/2 1 1/2
20,000	Fowler-Waring Cables, Nos. 301 to 20,300 ... (£4 10s. only paid)	5	2 — 3	2 — 3	...
180,227	Globe Telegraph and Trust, Limited	10	9 1/2 — 9 1/2	9 1/2 — 9 1/2	9 1/2 9 1/2
180,042	Do. do. 6 p. c. Preference	10	14 1/2 — 15 1/2	14 1/2 — 15 1/2	15 1/2 14 1/2
150,000	Great Northern Tel. Company of Copenhagen	10	18 1/2 — 19 1/2	18 1/2 — 19 1/2	18 1/2 18 1/2
220,000/	Do. do. 5 p. c. Debs. (issue of 1883)	100	106 — 109	106 — 109	...
12,134/	Greenwood and Batley, Ltd., Ordinary, Nos. 4667 to 14,000	10	8 — 8 1/2	8 — 8 1/2	...
9,600/	Do. do. 7 p. c. Cumulative Preference, Nos. 2,667 to 8,000	10	10 — 11	10 — 11	...
41,600	India-Rubber, Gutta Percha and Telegraph Works, Limited	10	19 — 20	19 — 20	19 1/2 19 1/2
200,000/	Do. do. 4 1/2 p. c., Deb., 1896	100	104 — 106	104 — 106	...
17,000	Indo-European Telegraph, Limited	25	41 — 43	41 — 43	42 1/2 42 1/2
11,334	International Okonite, Ltd., Ordinary Nos. 22,667 to 34,000	10	7 1/2 — 8 1/2	7 1/2 — 8 1/2	...
11,334	Do. do. Preference Nos. 5,667 to 17,000	10	9 1/2 — 9 1/2	9 1/2 — 9 1/2	...
38,348	London Platino-Brazilian Telegraph, Limited	10	6 1/2 — 7 1/2	6 1/2 — 7 1/2	...
100,000/	Do. do. 6 p. c. Debentures	100	107 — 110	107 — 110	...
43,900	*Metropolitan Electric Supply, Ltd., Nos. 6,101 to 50,000 (£9 paid)	10	9 1/2 — 10 1/2	9 1/2 — 10 1/2	10 9 1/2
447,234/	National Telephone, Limited, Nos. 1 to 438,984	5	4 1/2 — 4 1/2	4 1/2 — 4 1/2	4 1/2 4 1/2
15,000	Do. do. 6 p. c. Cum., 1st Preference	10	12 1/2 — 13 1/2	12 1/2 — 13 1/2	...
15,000	Do. do. 6 p. c. Cum. 2nd Preference	10	12 1/2 — 13	12 1/2 — 13	...
420,000/	Do. do. 4 1/2 p. c. Deb. Stock Prov. Certs. fully paid	...	105 — 107	105 — 107	106 1/2 106 1/2
6,318/	Notting Hill Electric Lighting Company, Limited, £8 paid	10	3 1/2 — 4 1/2	3 1/2 — 4 1/2	...
220,000/	Oriental Telephone, Ltd., Nos. 80,001 to 300,000 (11s. only paid)	1	1 1/2 — 1 1/2	1 1/2 — 1 1/2	...
9,000/	Reuter's Limited	8	8 — 8 1/2	8 — 8 1/2	...
18,680	St. James's & Pall Mall Electric Light Co., Ltd., Ord., 101—18,780	5	6 1/2 — 7 1/2	6 1/2 — 7 1/2	...
7,900	Do. do. do. 7 per cent. pref.	2	4 1/2 — 4 1/2	4 1/2 — 4 1/2	4 1/2 4 1/2
3,381	Submarine Cables Trust	Cert.	117 — 121	117 — 121	...
78,949	Swan United Electric Light, Limited (£3 1/2 only paid)	5	4 1/2 — 5	4 1/2 — 5	4 1/2 4 1/2
37,350	Telegraph Construction and Maintenance, Limited	12	42 — 44	42 — 44	43 1/2 43 1/2
150,000/	Do. do. do. 5 p. c. Bonds, red. 1894	100	101 — 104	101 — 104	...
146,370/	United River Plate Telephone, Limited	5	1 1/2 — 2 1/2	1 1/2 — 2 1/2	...
3,200/	Do. do. 5 p. c. Debenture Stock	Stock	85 — 95	85 — 95	...
15,609	Do. do. 7 p. c. Debs., Nos. 1 to 1,000	100	...	...	...
281,400/	West African Telegraph, Limited, Nos. 7,501 to 23,109	10	8 — 9	8 — 9	...
30,000	Do. do. do. 5 p. c. Debentures	100	96 — 99	97 — 100	98 1/2 98 1/2
150,000/	West Coast of America Telegraph, Limited	10	2 1/2 — 3 1/2	2 1/2 — 3 1/2	3 1/2 3 1/2
67,007/	Do. do. do. 8 p. c. Debs., repayable 1902	100	97 — 102	97 — 102	...
30,364/	Western and Brazilian Telegraph, Limited	15	10 1/2 — 11 1/2	10 1/2 — 11 1/2	11 1/2 11 1/2
30,364/	Do. do. do. 5 p. c. Cum. Preferred	7 1/2	6 1/2 — 7	6 1/2 — 7	7 6 1/2
189,700/	Do. do. do. 5 p. c. Deferred	7 1/2	4 1/2 — 4 1/2	4 1/2 — 4 1/2	4 1/2 4 1/2
237,200/	Do. do. do. 6 p. c. Debentures "A," 1910	100	102 — 105	102 — 105	...
88,321	Do. do. do. 6 p. c. Mort. Debs., series "B" of '80, red. Feb., 1910	100	101 — 104	102 — 105	104 1/2 104 1/2
34,563	West India and Panama Telegraph, Limited	10	1 1/2 — 2 1/2	1 1/2 — 2 1/2	2 1 1/2
4,669	Do. do. do. 6 p. c. 1st Preference	10	10 — 10 1/2	10 — 10 1/2	10 1/2 10 1/2
\$1,336,000	Do. do. do. 6 p. c. 2nd Preference	10	9 — 10	9 — 10	...
173,100/	Western Union of U.S. Tel., 7 p. c. 1st Mortgage (Building) Bonds	\$1,000	117 — 122	117 — 122	...
42,853	Do. do. do. 6 p. c. Sterling Bonds	100	101 — 105	101 — 105	...
	*Westminster Electric Supply Corp., Ord., Nos. 101 to 42,953	5	5 — 5 1/2	5 1/2 — 5 1/2	5 1/2 5 1/2

* Subject to Founders' Shares.

LATEST PROCURABLE QUOTATIONS OF SECURITIES NOT OFFICIALLY QUOTED.

Blackpool Electric Tramway Company, Limited, £10 (£6 1/2 paid), 7 1/2—7 1/2.—City of London Electric Lighting (Pioneer), Shares of £50, fully paid, 60—62.—Ordinary of £10 each, £2 paid, 2.—Elmore's Austrian Copper Depositing, 15s., 25s., £2 share issued at 10s. prem., fully paid, 1—1 1/2.—Elmore's Priorities, 3 1/2—4 1/2.—House to House Company (£5 paid) 4 1/2—5.—Liverpool Electric Supply, £3 paid, 2 1/2—2 1/2.—London Electric Supply Corporation, Ordinary (£5 paid), 2—2 1/2.—Manchester, Edison and Swan Company, £9 (£1 paid) 3—3.—National Telephone Debentures, 2 1/2—3 prem.—Woodhouse and Rawson Ordinary of £5 (£2 10s. paid), 2 1/2—2 1/2.—£5 Preference, fully paid 3 1/2—4.—Debentures 90—95.—Wards Electric Car, £10 paid, 1/2—1.

BANK RATE OF DISCOUNT.—2 1/2 per cent. (2nd July, 1891).

THE LONDON COUNTY COUNCIL AND
ELECTRICITY.

THE report of the year's work of the London County Council, just issued, does not devote any special chapter to its proceedings with regard to electrical matters, but scattered about the volume are various references to the subject which it may be as well to record in epitome.

The first allusion to electric lighting occurs in the chairman's (Sir John Lubbock's) address, which says that legislation in connection therewith threw a great deal of extra labour on the Highways Committee. The legislation of 1882 discouraged enterprise in that direction, but the disadvantages were greatly reduced by the Act of 1888, and the council had, during the last year (March, 1890, to March, 1891), sanctioned the laying of 137 miles of mains, in addition to innumerable service lines to particular consumers. Of these mains 86 miles were of high tension and 51 of low tension.

THE FIRE BRIGADE AND ELECTRICITY.

The Fire Brigade, the report says, has found the electric fire alarms of great service, no less than 1,907 alarms having been given by means of them in 1890. 75 new call points had been completed and put in working order, making 400 in all, and the number is being increased weekly. As rapidly as possible the direct radial system is being applied to all call points, instead of having them on circuits, only one point of which is in communication with a fire station. There are 73 lines of communication by telephone between fire brigade stations, and 21 between fire brigade and police stations. Electric communication also exists between five stations, and more than 70 public and other buildings.

THE HIGHWAYS COMMITTEE AND ELECTRICAL MATTERS.

The report of the 'Highways Committee first points out that the Act of 1882, which gave local bodies compulsory powers of purchase over electrical companies at the end of 21 years, checked the development of electric lighting, and the Act of 1888 altered the clause relating to compulsory purchase, by doubling the number of years a company might hold its undertaking in its own hand. The effect was that in 1889 a large number of applications for provisional orders was made, and 10 received the sanction of Parliament. In 1890, 23 provisional orders and three Bills were deposited, and of these nine orders were confirmed by Parliament as follows:—

Short title of order.	Name of undertakers.	Area of supply.
Lambeth Electric Supply Order, 1890.	House-to-House Electric Light Supply Company, Limited.	Parish of St. Mary, Lambeth, (part of).
North London Electric Supply Order, 1890.	Do.	Parish of Islington.
St. James's Electric Lighting Order, 1890.	St. James's and Pall Mall Electric Light Company, Limited.	Parish of St. James, Westminster.
London Electric Supply Corporation Electric Lighting (Metropolitan) Order, 1890.	London Electric Supply Corporation, Limited.	Parish of St. George-the-Martyr, Southwark.
Wandsworth District Electric Supply Order, 1890.	House-to-House Electric Light Supply Company, Limited.	Parish of Camberwell (part of). The district of the Wandsworth District Board of Works, excluding Wandsworth and Putney Bridges.
The Crystal Palace and District Electric Lighting Order, 1890.	The Electric Installation and Maintenance Company, Limited.	Parish of Lambeth (part of). Parish of Camberwell (part of). District of Lewisham Board of Works (part of). District of Beckenham Local Board (part of). Borough of Croydon.
Metropolitan Electric Supply Company (Paddington) Lighting Order, 1890.	The Metropolitan Electric Supply Company, Limited.	Parish of Paddington.
City of London Electric Lighting (Brush) Order, 1890.	The Brush Electrical Engineering Company, Limited.	The City of London (part of).
City of London (East District) Electric Lighting Order, 1890.	The Laing, Wharton, and Down Construction Syndicate, Ltd.	The City of London (part of).

The report goes on to detail the matters connected with these provisional orders, and the proceedings of companies, which required the attention of the committee, and states that they, in order to facilitate business, where service lines were to be fixed for mains already laid, agreed to accept four days' instead of one month's notice. Twelve new provisional orders had been deposited with the Board of Trade this year up to the end of March. The committee desired their amendment in various respects to make them correspond with the orders of the previous Session, and reserved the right to submit other amendments at a later stage. The committee state that "the general policy of the council with reference to applications for new orders, has been to object to more than two competing companies in the same area. The advantages of this policy are twofold. It prevents undue disturbance of the streets at the present time, and also unnecessary complication in the event of the purchase of the undertakings at the expiration of the statutory period." The Electric Meter Testing Station at 42 and 43, Cranbourne Street, will shortly be in full working order. During the year the council has dealt with 123 notices, many referring to works extending over large areas, under Electric Lighting Orders and Acts.

THE ELECTRIC LIGHT IN THE COUNCIL'S OFFICES.

The Office Committee report:—"Advantage has been taken of the electric current having been introduced into the office for the lighting of the council chamber, to light by electricity certain of the rooms in the offices in which better means of lighting were much needed.

Benefit having been derived by the adoption of the electric light in these rooms, other rooms are now about to be provided with it."

ELECTRIC RAILWAYS.

The Parliamentary Committee, in detailing their action in connection with the Central London Railway Bill, state that they first proposed to oppose it partly on the ground that the possibility of working such a railway advantageously by electrical traction had not been practically demonstrated; but, subsequently, to gain a *locus standi*, prepared a petition against the Bill, and confined its opposition to taking the necessary steps to protect the sewers and other interests of the council.

THE ELECTRIC TRANSMISSION OF POWER.*

By GISBERT KAPP.

(Concluded from page 233.)

Originally the motors were intended to be pure shunt machines, but it was soon found that owing to the very small armature resistance and armature reaction, it was very difficult to get the load equally divided between them. Mr. Brown, to overcome this difficulty, hit upon the ingenious device of making the machines mutually control each other by putting on demagnetising main coils, and crossing the connections between armatures and fields, so that the machine which might at any moment develop a tendency to take more than its fair share of current would have its field strengthened by the deficiency of current passing through its main turns to the other armature, and would thus immediately raise its counter E.M.F., and check the excess of current, whilst the other machine which was not taking enough current would have its field weakened, and would thus be forced to take more current. It is clear that by this cross connection even a neglect on the part of the attendant to set the brushes properly cannot materially influence the even division of current and load between the two machines. At the same time the demagnetising influence of the main coils has the same effect as if the armature reaction were increased, and insures thus constancy of speed, as I have shown you experimentally last week. In the diagram, fig. 6, the machines are represented as if they had only two poles each. This I have done to make the diagram as simple as possible, and for the same reason I have shown the shunt and main coils on separate magnet limbs, but you will have no difficulty in translating in your own mind this principle of circuit connections to multipolar machines.

It may interest you to have a few details of a commercial nature regarding this transmission plant. The manufacturers have guaranteed a commercial efficiency at ordinary full load of 78 per cent., also that the machines must be capable of transmitting an excess of 20 per cent. over their normal power for one hour and a-half without damage. The wear of one set of brushes to be not less than 2,000 hours, and the life of a commutator not less than 20,000 hours. The variation of speed of the motors between running idle and under full load not to exceed 3 per cent. The total cost of the electrical part of the plant, including cable towers and erection, was £6,800, or £13 12s. per net horse-power delivered.

I have occupied some time in putting before you this transmission plant, because exact information about successful engineering work is of great value to practical men; and the Schaffhausen plant is certainly one of the best and most successful examples I could have chosen. The power transmitted is certainly large, according to our present ideas, but there is good reason to believe that—in point of magnitude, at any rate—this transmission will very soon be eclipsed by other work of this kind. There are projects afloat for utilising the power of the Rhine, near Bale, to the tune of tens of thousands of horse-power, and at Niagara, as you all know, a total of 125,000 horse-power, or a little over 3½ per cent. of the total power of Niagara, is to be taken from the Falls and transmitted to various distances, the longest distance being some 20 miles. I am not in a position to give you details of any of the schemes which have been submitted to the Niagara Commission, since these are the property of the Cataract Company, but by the courtesy of several members of the commission, notably Dr. Coleman Sellers, I am able to give you a general outline of the schemes. My object in applying to the Niagara Commission for information of this kind was to obtain some indication of the opinions which leading modern engineers entertain of electric power transmission, and to put the result of my enquiry before you. Let the general condition of the Niagara scheme may not be quite familiar to all of you, I shall now throw upon the screen a picture of the Falls, and give you very briefly an outline of the objects for which the Cataract Company has been established.

Of the immense power represented by the descent of the river from its upper to its lower level over the Falls (about 3½ million horse-power), there is utilised at present an aggregate of only about 5,000 horse-power in the mills you see on the left of the picture. The water is brought to these mills by a surface canal from the upper reaches of the river, and, after passing through turbines, is discharged into the open air about half-way between the level of the ground and the level of the river below the tail races, forming a number of miniature waterfalls. Only about half the available head is therefore utilised. If the system adopted hitherto could be followed in future, there would be little difficulty in establishing a station for the generation of any amount of power in this locality, but there is a strong tide of public opinion against the establishment of any more hydraulic works on the river bank, to say nothing of the difficulty of

finding room for them and the open air canal which would be required. The Cataract Company have therefore resolved to carry out their operations, to a great extent, underground, and at the present moment are driving a tunnel 30 feet high by 20 feet wide, and about 6,700 feet long, which is to serve as a tail race for the water coming away from their power station. This tunnel is shown on the picture by two dotted lines, and its mouth is partly submerged under the level of the lower river. The total fall between the upper and lower river is 200 feet, and the net fall available for the turbines is 140 feet. The fact that the tail race is a tunnel necessitates the turbines being placed at least 110 feet underground, since the suction tube of a turbine cannot be made longer than the column of water which can be balanced by atmospheric pressure, and this increases very materially the engineering difficulties of the work.

Last summer the Cataract Company invited a limited number of engineers to send in projects for the creation and transmission of power, and instituted a commission, under the presidency of Sir William Thomson, to investigate and report on the projects. There were in all 20 competitors, but of these only 14 complied with the programme drawn up by the commission, and were therefore held to be qualified to have their projects examined. Of these 14, eight competitors sent in combined projects for the creation and transmission of power, four referred only to the creation, and two only to the transmission of the power. The point of interest to us is what methods were suggested by the ten qualified competitors in transmission. The question is somewhat complicated by the fact that some competitors have suggested mixed systems of transmission, and that in classifying the schemes into electrical, pneumatic, and hydraulic, we must count some competitors twice over. On this basis I find that the following represents the transmission projects:—Electrical, 7; pneumatic, 6; hydraulic, 2. It is certainly remarkable that the balance in favour of electric transmission should be so small. And it is equally remarkable that there should have been as many as six competitors who either wholly or partly advocated pneumatic transmission. The experience of colliery managers goes to show that even over the comparatively short distances over which they use pneumatic transmission, the total efficiency lies generally between 20 and 30 per cent., and does certainly not exceed 40 per cent. We cannot suppose that engineers who have sent in pneumatic projects are ignorant of this fact, or at any rate we must suppose that the majority of them are quite aware that high efficiency cannot be expected from compressed air transmission. If, nevertheless, they have adopted compressed air in preference to electricity, it must be for one of two reasons. Either they have no confidence in the capabilities of electric transmission, or they consider the cost so high that the interest on the extra capital and the greater depreciation of the plant will more than counterbalance the advantage of high efficiency. It cannot be denied that in the present state of our knowledge of electric transmission, there is some ground for both these views. The Niagara problem is unique both in magnitude and distance, and I am bound to confess that we electrical engineers are at the present moment not quite prepared to face it. At the same time I must say that I feel convinced that in a few years from now there will be not one, but a dozen men ready to face this problem with a very good chance of successfully solving it. As a matter of fact, we are at present on the threshold of a new system of electric power transmission. The old system of using continuous currents and ordinary dynamos has been perfected to a point which leaves little to be desired, but it has its limits, and, unfortunately, the Niagara problem, or at least a part of it, is just a little beyond these limits. Hence we find that only about half of the competitors have had the courage to propose electric transmission. Of these, only two suggested the use of alternating currents at voltages of 5,000 and 10,000 respectively; the others followed the old lines of continuous current transmission at voltages varying between 1,600 and 4,500 volts.

This brings me to the consideration of a subject which is of great importance, not only in regard to the Niagara problem, but to long distance transmission generally, namely, the limits of distance up to which the usual system of transmission is practicable. If you will refer to the Table giving the cost of transmission plants, giving in my last lecture, you will find that, for large powers at any rate, an increase of distance up to four or five miles does not make the cost prohibitive, and you will conclude from these figures that, within a five mile limit, the old system of electric transmission is certainly feasible. How much farther you might go is a matter for theoretical consideration; the Table does not help you much, as the only example of a very long distance transmission is one where the power is small, and is therefore, in a certain sense, misleading. I have given you a formula by which you can calculate the most economical voltage for any distance; and if you do this for many cases, taking, for instance, 500 horse-power as your unit of power, you will find that as the distance increases beyond about five miles, the economical voltage begins to grow beyond the limit which might be considered practicable for one machine. It is quite impossible to lay down hard and fast rules. Under certain conditions, especially if you have to transmit cheap water-power, you may possibly reach a distance of 10 miles before getting to the limit of voltage; but whatever may be the special conditions of the problem, there is a limit of distance beyond which a single machine will not reach. "Very well, then," you might say, "if a single machine cannot be made to give the required pressure, let us put two or three machines in series." To correctly appreciate such a suggestion, let us first of all see what limits the voltage of a machine. Two things limit it, the commutator and the general insulation. Practical dynamo makers will tell you that in large machines they are quite prepared to put 1,000 volts on the usual Pacinotti commutator—if necessary, they will go to 2,000 volts, but with some misgiving; and if you ask them to make a machine for 3,000 volts, they will, as likely as not, refuse. I do not refer to the Thomson-Houston or Brush machines, which have special commutators, but to large machines giving an even current and a

high efficiency, such as we require in the transmission of power. We may thus conclude that 2,000, or, at the outside, 3,000 volts, is the limit of voltage to be obtained from a single commutator. But the general insulation of the machine must also stand this pressure, and where, as in dynamos and motors, the insulation consists of cotton, paper, fibre, varnish, and like materials, which are subjected not only to electrical, but also to mechanical strains, 3,000 volts is quite high enough for safe working. The commutator difficulty can, of course, be got over by putting several machines in series, and insulating their frames from earth. The difficulty of general insulation can, however, not be met so easily. This you will see by referring to fig. 7.

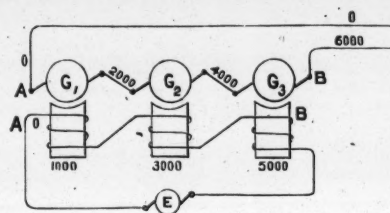


FIG. 7.

which shows, diagrammatically, three 2,000-volt machines placed in series. Shunt excitation at the high pressure of 2,000 volts is, of course, out of the question; series excitation introduces complication and certain difficulties, especially at the motor station; and separate excitation, although simple and easily worked, has the disadvantage of throwing great electrical strains upon the insulation between the exciting coils and the frames of the machines. Imagine, for instance, that there is a weak place at A, between the exciting coil and the frame of the first machine, then the strain between the exciting coil and the frame of the third machine at B will be about 6,000 volts, even if all the machines are perfectly insulated from earth. With series self-exciting machines, the strain would, of course, be limited to 2,000 volts, but there still remains the difficulty that all the armatures would have to be mechanically connected by insulated couplings, and there would also be great danger in touching even the iron frame of any machine. You see the use of several machines in series is not such an easy matter as it may look at the first glance, and this method has, as far as I know, only been adopted in cases where the total voltage was under 2,000.

The net result of our investigation may be stated by saying that the electric transmission of power by continuous currents is economical and safe up to distances for which the most economical voltage does not exceed 2,000, or, at the outside, 3,000 volts, but that beyond these distances some other system must be applied. That this other system must also be electrical is evident, for we know perfectly well that distances beyond the reach of our present electric transmission systems are hopelessly beyond the reach of lines of shafting, flying ropes, air, or water. Now what is this new electrical system which shall enable us to carry power over ten or twenty, or perhaps a hundred miles?

In attempting to answer this question I must perforce leave the safe ground of solid facts and engineering practice, and enter into the domain of speculation. Yet speculation based upon experimental results which in themselves are as reliable as were those experimental results which have led to the practical development of electric power transmission as we know it now.

The starting point in the theory which I have now to bring before you is the well known disc or Arago. If a copper disc be rapidly revolved under a compass needle, the latter is also set into rotation. I am able to show you this experiment, by the kindness of the Science and Art Department, who have lent me the apparatus you see before you. Between the copper disc and the compass needle is placed a sheet of glass so as to prevent air currents from affecting the needle. If I set the disc in motion you see that the magnet very soon follows. To make the motion of the latter better visible, coloured pieces of paper are attached to the poles. Now the fact that the magnet revolves is evidently due to their acting upon it some mechanical force. The explanation is perfectly simple. The disc, in passing under the poles of the magnet, becomes the seat of a very complex system of electromotive forces, which produce an equally complex system of currents. Some of these currents cross the path of the lines of force emanating from the magnet, and thus mechanical forces are set up between the disc and the magnet, causing the latter to rotate. It is as though there existed between the disc and the magnet a kind of electro-magnetic friction by which the magnet is dragged after the disc. Since all motion is relative, it is perfectly clear that we might regard the magnet as revolving, and then the disc will be dragged after it. With the apparatus before you this experiment would not succeed, since the magnet is small and the disc is heavy; but if we were to employ a very strong magnet, and revolve it rapidly enough, there would be no difficulty in setting the disc in rotation, and even obtaining power from it. I have said a moment ago that the system of currents set up in the disc is very complex, and you will easily see that only those currents which are more or less radial, and of these only their radial components, are instrumental in exerting mechanical force, whilst all the other currents represent simply so much waste power. To make an efficient machine we must, therefore, not employ a continuous disc, but a system of conductors, so arranged as to force the currents to flow as much as possible in a radial sense, and only in those places which are immediately under the influence of the magnetic field. Or, better still, we may abandon the disc shape of conductors altogether, and substitute an armature with a laminated iron core of the drum type, seen end on in fig. 8.

and use, instead of a straight magnet, a horse-shoe magnet, so shaped as to bring its poles, N , S , to opposite sides of the drum, and wind the latter with a number of coils closed in themselves. If we now revolve the magnet, strong currents will be generated in each coil successively, and a very strong torque will be exerted on the armature. The torque will, in fact, be comparable to that required to revolve an ordinary continuous current drum armature in a strong field, if we short-circuit the brushes. Here, you see, we have, by applying a few very obvious improvements to the Arago disc, at once obtained a machine of very considerable power. Imagine both the magnet and the armature mounted on independent spindles (not shown in the diagram, but passing both at right angles through the centre of the figure), then it is perfectly clear that power given to the magnet spindle is transmitted, by electro-magnetic induction, to the armature; and a large portion of it may, therefore, be obtained again from the armature spindle. Here we have, certainly, transmission of



FIG. 8.

power, but not of the kind we require, since the distance of transmission is nothing. Now, what we want to do is to so alter our machine so as to separate the two parts. We want the magnet in one place and the armature in another place, miles away. If, in this case, we succeed in transmitting rotation from the magnet to the armature, then we shall have solved the problem. This problem has been solved by an Italian electrician, Prof. Galileo Ferraris, of Turin, who, early in 1888, communicated to the Turin Academy the results of his investigation on rotating magnetic fields produced by alternating currents. To clearly see the bearing which Ferraris's investigation has on our problem, let us inquire what it is we want at the motor station. We want there an armature, as shown in fig. 8, and a magnetic field, the lines of which shall pass through the armature, and shall revolve round its centre. Whether the field is due to a real magnet, or is produced by any other means, is immaterial; and it is the merit of Ferraris to have shown us how to produce such a revolving field without the use of a real magnet, but simply by the use of two distinct alternating currents passing through fixed coils.

As the subject is new, and will not be found in any of the numerous text-books dealing with electrical engineering, you will perhaps not think it out of place if I put it before you in rather an elementary manner, beginning with the simplest possible case, and passing gradually to the more complicated cases. Assume, then, a combination of apparatus, as shown in fig. 9. Here you have, on the left, an

FIG. 9.

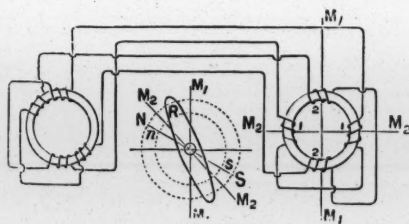
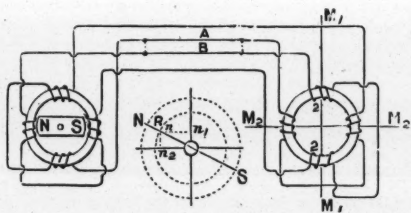


FIG. 10

annular iron core wound with two coils, which are connected in series, and to a pair of line wires going to a similar coil on the right, which may be at any distance. Into the circular space enclosed by the first coil we put a straight bar magnet, N , S , which can revolve round the centre. As the poles sweep past the wire turns, an E.M.F. is induced, and a current is caused to flow, the direction of which changes twice in every revolution. We have here, in fact, an ordinary alternating current generator with stationary armature, and revolving field magnet. By suitably proportioning and placing the various parts of the apparatus, we can make the E.M.F. and the current curve of a true sine character; and, in order to simplify the treatment, I shall assume that in this, and in the cases which follow, the design is such that all the E.M.F. and current waves follow the sine law. The alternating current, in passing through the coils on the right, magnetises the iron core, so as to develop north and south polarity in the line, $M_1 M_2$. The effect is the same as if we placed into the ring a

vertical magnet which is collapsible, the two poles shrinking into a point at the moment that the current strength is zero, and coming apart vertically as the current increases. We must imagine this magnet alternately shrinking into nothing and growing larger and stronger; also reversing its polarity each time that it passes through its zero condition. In the apparatus shown by fig. 9, therefore, rotation of a real magnet on the left produces merely an oscillating magnetic field on the right. As you know, a magnetic field may be represented graphically, in direction and magnitude, by a straight line; and, in this particular case, the line so representing the oscillating field is the projection of the radius, $o n$, on the vertical, $M_1 M_2$, if the length of the radius, $o n$, represents the strength of the field at maximum current. At the moment to which the diagram refers, our collapsible magnet will, therefore, have grown to the strength represented by the length, $s_1 n_1$; and, if there were no lag, the real revolving magnet would, at that moment, occupy the position, $s \pi$. As there must be some loss in the transmission, I have shown π at a larger radius than n . If there is lag, then n and π will not lie on the same radius, but n will occupy, say, the position n' , and the strength of the oscillating field will be $n'_1 s'_1$. The practical effect of lag is this, that the revolving magnet will have passed the vertical position shown in the diagram by the time the current has reached its maximum; and I can, therefore, eliminate the lag from the graphic diagram, by assuming that the revolving magnet has been shifted back through an angle equal to the angle of lag in this diagram, but left in its true position in the diagram representing the apparatus itself. In fig. 9, the coils on the ring on the right hand are placed on the horizontal diameter. If, as in fig. 10, I place them on the vertical diameter, the resulting oscillating field will be horizontal, namely, on the line, $M_2 M_1$; and the projection of n on the vertical must be taken over to the horizontal, as shown by the dotted quarter circle. Let us now suppose that we have both horizontal and vertical coils on the ring, as shown in this figure, then the combined effect of these coils will be to produce an oscillating field on the line, $n n$, the strength of the field being, as you will easily understand, about 40 per cent. greater than in either of the former cases; but still the field is not a revolving one. I can show you the production of an oscillating field, as here explained, by means of a mechanical model.

Up to the present, then, we have not advanced in the solution of our problem. We have produced at the distant point an oscillating field; but what we want there is a revolving field; and to get this we must duplicate the apparatus shown in fig. 9, by putting horizontal coils on the generator and vertical coils on the motor ring, in addition to the coils already there. This arrangement is shown in fig. 11. Now,

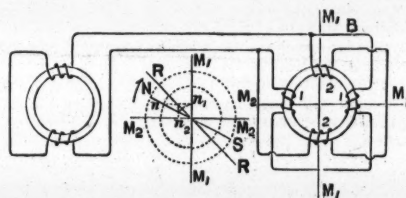


FIG. 11.

the field produced by the coils, 1 1, is given by the projection of $o n$ on the vertical; and that produced by the coils, 2 2, is given by the projection of $o n$ on the horizontal. The resultant of these two fields is, therefore, $o n$, the point, n , revolving round o as a centre on the circle, n . The effect of revolving a real magnet within the generator ring is, then, to produce a revolving magnetic field of the strength, $o n$, within the motor ring, a kind of revolving phantom magnet which, for our purpose, is quite as suitable as a real magnet. I can also show you this effect by means of the mechanical model.

You observe that in diagram 11 four wires are shown, connecting the generating and receiving machines. Now as the absolute potential of any of these wires may be chosen arbitrarily, there is obviously nothing against choosing it at such a value as will make it coincide with the absolute potential of another wire not belonging to the same circuit. We might thus, for instance, equalise the potential between the wires a and b by connecting them at either terminus, as shown by dotted lines, and not disturb in any way the satisfactory working of the machines. Or, better still, we may omit one of the wires altogether, and use the other as a common wire for both circuits, and thus reduce the total number of wires to three. The common wire must, however, have about 40 per cent. more carrying capacity, since the algebraical sum of the two currents is 1.4 times the strength of each current taken singly. Here you have, then, the theoretical solution of the problem of how to transmit power by alternating currents as indicated by Ferraris, but the first to attack this problem practically was Mr. Tesla, an American electrician, and such motors are therefore also known under the name of Tesla motors, though the name of "Ferraris motors" seems to me to be more appropriate, as distinguishing this motor from the two-wire Tesla motors, about which I shall say something presently. To carry out a power transmission by means of such a system, we must have at the generating station an alternator, the armature of which is wound with two circuits giving currents with a quarter period phase difference, three line wires, and a motor having a laminated field magnet, which is excited by coils placed alternately in the two circuits so as to produce a revolving field. The armature of this motor must have an iron core, surrounded with coils closed in themselves.

The necessity of using three-line wires is, to a certain extent, a disadvantage of this system, and several engineers, Mr. Tesla for-

most amongst them, have tried to improve the system in such way that two-line wires only should suffice. The methods suggested have this in common, that all aim at producing a difference in phase between the currents passing through the motor, without the use of a second set of coils on the generator. If we insert, for instance, a large inductionless resistance into the branch, B, in fig. 10, and a coil having very little resistance, but great self-induction, into the branch, A, the current in the coils, 1 1, will lag by a small amount behind the E.M.F. impulses of the generator, whilst the current in the coils, 2 2, will lag behind these impulses by a larger amount. The phase difference between the two currents can, of course, not amount to 90° , which angle is required for producing the best effect, but some difference of phase can certainly be produced in this way. The arrangement will, in fact, be equivalent to that shown in fig. 12, where

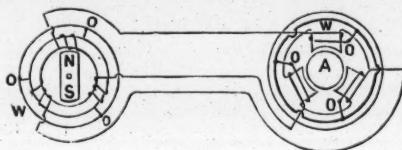


Fig. 12.

the distance between the two sets of coils on the generator is less than 90° .

An easy geometrical construction, which I need not explain at length, shows that in this case the path of either pole of what I have before called the revolving phantom magnet is an ellipse, but that it can be made to be circular by a dis-symmetrical arrangement of the coils on the motor, though in this case the diameter of the circle is much reduced. In either case the value of the machine as a power-producing appliance is also much reduced, whilst at the same time the efficiency must be low, owing to the waste of power in the resistance coil. I can also show you the action of this two-wire motor by means of the mechanical model.

Owing to the low efficiency and small power of the two-wire revolving field motor, its employment is necessarily restricted to cases where these defects are of little consequence, but for the transmission of large powers over long distances it is not suitable. For such a purpose we must have three wires, but this is not a great drawback since the cost of the line is but little increased by the necessity of splitting up the total weight of copper into three instead of into two wires. The revolving field motor has, however, the defect that it is not self-regulating. Its speed may be anything between zero and that speed which will give synchronism between the two machines accordingly as the mechanical load varies from a maximum to nothing. This defect can be overcome by combining with the armature in the motor a real magnet which will force the armature to keep step with the current, and thus insure a constant speed at varying loads. The motor will thus start with great power by virtue of the currents induced in the armature winding by the revolving field, and having reached the synchronising speed it will keep there by virtue of the interaction between the revolving field and the revolving magnet; it will, in fact, behave just like an ordinary alternator run as a motor, with this difference, however, that the ordinary alternator, if overloaded by 50 or 100 per cent., will be thrown out of step and come to rest, whereas the combined Ferraris and synchronising motor will always be ready to recover itself after the overload has been removed.

Since the discovery of Ferraris has been made public many engineers have turned their attention to revolving field motors, and especially to the modification of this principle, according to which three sets of coils are employed instead of two sets only. As far as I have been able to trace the history of this invention, the first to suggest the use of three coils were M. Tesla and Charles Bradley. The latter applied in the United States for a patent in 1888, which bears the number 409,450, and was granted on August 20th, 1889. Next comes Wenstrom with his British patent, No. 5,423, of 1890, and at about the same time Dobrowsky, in Berlin, had worked out a similar system. About a year ago, when I visited him at the works of the Berlin Electrical Company, he showed me such a three-wire motor in action, whilst shortly afterwards Charles Brown, of Oerlikon, took

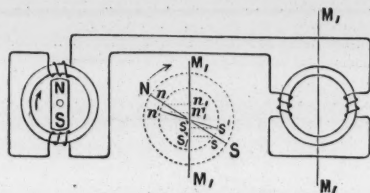


Fig. 13.

the matter up, and it may interest you to learn that he is at the present moment putting up a 500 horse-power transmission plant on this system between Bülach and Oerlikon, a distance of 15 miles. This transmission is intended to supply all the power required in the Oerlikon Works. The general principle forming the basis of the work done by these various inventors is illustrated in fig. 13. The generator contains a revolving field magnet, and an armature wound with three distinct coils. The end, o, of each coil is joined to a wire, w, common to all, and the three free ends are joined with the three-line

wires. At the receiving station there is a three-legged magnet, the coils on the legs being in connection with the line wires on the one side, and joined by a common wire, w, on the other side. It is easy to see that the rotation of the field magnet and generator will produce successive polarities in the legs of the receiving magnet, and that the general effect will be that of a revolving field. The armature, A, will, therefore, be set in rotation in the same way as is the case in the original Ferraris motor. This kind of transmission is known in Germany under the name of transmission by the "three-phase current," and it is likely that it will, ere long, become a strong rival to the ordinary alternating current.

The diagrams I have brought before you were all drawn for two-pole machines, as this was the simplest way of making the principles clear; but I need hardly say that, in practice, the machines are made of the multipolar type, in order to bring the speeds down to any desired value.

You will, perhaps, ask why we should go to the complication of three-line wires and a totally new type of motor, seeing that, with the ordinary dynamos and motors, such excellent results have been obtained, and that with only two-line wires. My answer is that, with this new system, we can greatly extend the distance of transmission. I have spoken, a short time ago, of the difficulties which the high voltage required in long-distance transmission, raised in connection with the commutators and general insulation of machines. Now, in the three-wire system of transmission, by alternating currents, we have no commutators, and, in fact, not even rubbing currents. One of our difficulties has, therefore, already vanished. As to the other, which has reference to the general insulation of the machines, it is easy to see how this may be overcome. We need only, instead of working direct, work through transformers. The insulation of transformers offers no difficulty whatever. I have here on the table a transformer of the type made by Messrs. Johnson and Phillips, which has been designed specially for high-pressure currents, and is provided with oil insulation. I have recently used two of these transformers for testing a Brooks line. In one transformer the pressure was raised from 2,400 to 17,000 volts, the high-pressure current was sent through the line, and, at the other end, it was again transformed down to 2,400 volts, and, finally, to 100 volts, for lighting glow lamps. The apparatus was kept running for several days without any difficulty. Mr. Brown informs me that he has with oil insulated transformers, even gone up to 36,000 volts, without breaking down the insulation, and the Bülach-Oerlikon transmission will be made at 25,000 volts, whereas the machine will work only at a few hundred volts. There is thus no difficulty in adopting whatever voltage is most economical in each case, and yet avoiding all danger, either to the attendant or to the machines themselves, at the generating and motor station.

I feel that I owe an apology for having occupied so much of your time with discussing a branch of power transmission which, to many of you, must seem to be purely theoretical, and hardly ripe for discussion. My excuse must be that I am very strongly convinced that some form of alternate current working will be the ultimate solution of the problem how to transmit power—possibly over all distances, but certainly over very long distances—and that I was desirous of directing the attention of electrical engineers to a subject in which much work may still be done.

ELECTRIC MACHINE TOOLS.

In concluding my lectures, I wish to bring before you a few examples of short-distance transmission as applied to electric machine tools. This branch of our subject has of late years received considerable development at the hands of various English firms, and, thanks to their enterprise and perseverance, is now a well-established method in several engineering works.

As an example, I may mention the Leven Shipyard of Messrs. Denny Brothers, at Dunbarton, and Mr. Archibald Denny has been good enough to give me some particulars of the work carried on by his firm in this direction. I cannot do better than quote his words:—"In our yard and engine works we have numerous instances of electric transmission of power. In our experimental tank we drive our model cutting machine and small lathes by means of a 3 horse-power Immisch motor. In our upholstery department we drive six sewing machines, with a 2 horse-power Immisch motor; of course in this case there is a large margin of power. In our experimental tank we have also used small motors for driving small model paddle wheels in our experimental models, and have obtained in this way most valuable data, which we could not have got by any other means. The power for all this work is obtained from a dynamo driven by an ordinary line of shafting in our joiner's shaft. We also use a 3 horse-power motor in the yard for boring the stern tubes in place; before this we used a portable engine, which necessitated an attendant to fire the boiler and carry water to it."

"During the holidays, when all the boilers are off except one, we occasionally put down a motor for driving some lathes to do repair work, and this saves an attendant at more than one boiler. In our engine works the pattern shop is driven by a 15 horse-power Manchester motor, the dynamo being driven off the line of shafting in the fitting shop."

You see, Messrs. Denny Brothers find electric power transmission so handy, economical, and convenient, that they make extensive use of it. They employ a special tool for drilling the sole plates of engines, which I now show on the screen. The weight of the machine is sufficient for the pressure required on the drill, and the whole apparatus being mounted on wheels, it can be rapidly shifted. The machine will drill $1\frac{1}{4}$ -inch holes through two thicknesses of inch plate in three minutes.

Another machine used at Leven Shipyard is a special drill for butt straps. The motor and gear are mounted on a stout vertical column with horizontal arm, so as to give adjustment in both directions, the column being bolted to the strap, as shown. The machine will take

in straps 50 inches deep by 23 inches between outer rows of holes, and is chiefly used for drilling sheer strake double butt straps. The outside strap is first punched and counter-sunk, and the machine drills through the plate and inside strap. The machine is worked by two men—one hole-borer and one labourer—and will do three straps, or about 180 holes per day.

The rivet holes in boiler furnaces are also drilled by an electric tool, which I illustrate on the screen. The machine has a tripod stand arranged to go inside the furnace, but it has also holding-on magnets for outside work. One man with this machine does the work which formerly required three to four men.

No account of electric machine tools would be complete if it did not include the work done by Mr. Rowan, who has been very successful in developing this branch of power transmission. Amongst the improvements Mr. Rowan introduced is that of holding-on magnets, whereby the tools are firmly held in place while at work, and yet by the mere turning of a switch become liberated and can be shifted to a new position with the greatest ease. You see on the screen some of Mr. Rowland's drillers as applied to ship-work. The apparatus is suspended on a chain over the ship's side and supplied with current by means of two flexible wires. I need not detain you with a description of the picture on the screen because I can show you the actual machine at work, thanks to the kindness of Messrs. M'Whirter, Fergusson & Co., the makers, who have sent me one of their latest machines for this lecture.

I am also indebted to Mr. Webb, the locomotive superintendent of the London and North Western Railway, for the loan of one of his electric tube cutters which you see before you, and which I shall now work. A diagram of this machine to an enlarged scale is on the wall.

These few examples of what are properly called electric machine tools must suffice for this lecture, but there is another class of apparatus, namely, electric mining machines, which ought to be included in our subject. Several firms, both here and abroad, have of late years devoted considerable attention to the application of electric power to mining operations, such as pumping, hauling, coal-cutting, and drilling. Messrs. Gooden & Co., for instance, have during the last four years steadily and perseveringly worked out many of the difficult problems in connection with this subject, and I am indebted to this firm for the loan of the apparatus you see here, and also to Mr. Atkinson for assisting me in setting the machines up. After the excellent paper which Mr. Atkinson read at the Institution of Civil Engineers, only a few weeks ago, it would be occupying your time uselessly if I were to give any lengthy description of these machines. I shall, therefore, merely show two types of mining motor on the screen, and show you a drill at work.

I have in these lectures not attempted to treat exhaustively any one branch of the subject, but have rather endeavoured to pass the various branches in rapid review, so that you may know what electric transmission of power can do and what it cannot do. We hear nowadays very frequently the assertion that electricity is but in its infancy, and will ere long be the sole motive power, driving our main line trains, speeding our vessels across the ocean, and running our factories. These are idle dreams, ideas put forward by persons who have forgotten or have never learned the fundamental laws of nature. Do not waste time over such ideas, for there are other more hopeful problems, such as the utilisation of water-power generally, of waste coal at the pit's mouth, the working of railways in mountainous districts, where water-power is abundant all along the line, the working of tramways, underground town railways, the application of electric power to such purposes for which now small auxiliary steam engines are employed, and last, but not least, its application to machine tools and other special machinery, of which I have given you examples to-night.

NEW PATENTS—1891.

13,465. "Improvements in electrical automatic stopping apparatus for webt pile cutting machines." W. GADD and O. DREY. Dated August 10th.

13,492. "A method and apparatus for electrical propulsion of vehicles." F. E. ELMORE. Dated August 10th.

13,503. "Improvements in electric machines and apparatuses for differential phase alternating currents." M. von DOLIVO-DOBROWOLSKY and the company ALLGEMEINE ELEKTRICITÄTS GESELLSCHAFT. Dated August 10th. (Complete.)

13,528. "Improved electric time registering apparatus for use in cabs and the like." A. DOUGLASS. Dated August 11th.

13,529. "Improvements in methods and apparatus for obtaining and utilising electric light." J. A. BRIGGS. Dated August 11th.

13,553. "Improvements in electrically heated ovens." W. MITCHELL. Dated August 11th. (Complete.)

13,554. "Improvements in electric steam generators." W. MITCHELL. Dated August 11th. (Complete.)

13,558. "Improvements in unipolar continuous current magneto or dynamo-electric machines." J. CAUDERAY. Dated August 11th.

13,589. "Improvements in electric conductors." G. E. HEYL. Dated August 12th.

13,627. "An improved alternating electric current motor." W. B. BRAIN and A. J. ARNOT. Dated August 12th. (Complete.)

13,628. "Improvements in dynamos for generating electricity." W. HARTNELL. Dated August 13th.

13,692. "Improvements in electric arc lamps." A. H. MITCHELL-JONES. Dated August 14th.

13,705. "An improved coupling for connecting electric wires." A. SHIELDS. Dated August 14th.

13,714. "Improvements in and relating to apparatus for measuring electric currents." H. W. MILLER. Dated August 14th.

13,753. "Improvements in telegraphic call boxes." A. M. CLARK. (Communicated by J. G. Noyes, United States.) Dated August 14th. (Complete.)

13,754. "Improvements in and relating to electric tramways and to vehicles therefor." W. S. RICHARDS and G. B. JAMES. Dated August 14th.

13,802. "Improved electric current generator for ordinary and multiple phase alternating currents." J. SOHLMAN. Dated August 15th.

13,816. "Improvements in appliances for splicing or connecting poles for use in scaffolding or electrical purposes." J. MUNRO. Dated August 15th.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1890.

3,096. "Improvements in electric meters." S. Z. DE FERRANTI. Dated February 26th. 11d. Has for its object improvements in electrical meters, such as are described in specifications of patents Nos. 5,926, 1883, and 701, 1887, in which a bath of mercury is set into rotation by a passing current, and in which the rotation of the mercury is recorded by causing it to impart a revolving motion to an axis whose revolutions are recorded by recording the mechanism. The inventor now forms with a main coil, through which the current to be measured passes, and an additional coil through which a branch circuit from the mains is allowed to pass as described in the specification, No. 701, 1887, and these two coils are placed one above the other. 12 claims.

4,650. "Improvements in means or apparatus for producing periodical or intermittent motion by electricity." H. B. PALMER. Dated March 25th. 11d. Chiefly consists in the combination with an electric contact maker of an automatic gravity balance containing mercury or other suitable liquid or medium, the said contact maker having its position periodically and automatically changed or altered, thereby alternately making and breaking, or closing and interrupting an electric circuit, and bringing into action solenoids or electromagnets or permanent magnets, or any or all of these in combination. 5 claims.

4,824. "Improvements in armatures for dynamo electric machines." J. NEBEL. Dated March 27th. 8d. Relates to winding the armature with two, three or more sets of convolutions side by side, each set connected to its own set of commutator segments, thus reducing the sectional area required for each conductor to one-half, one-third or other fraction of the area required for each conductor as it is usually wound the number of commutator segments being proportionally increased. 1 claim.

5,135. "Improvements in cores for converters and for other electrical apparatus." R. BELFIELD. (Partly communicated from abroad by the Westinghouse Electric Company, of America.) Dated April 2nd. 8d. Has for its object the manufacture of laminated cores of mild steel for converters and other electrical apparatus in such manner as to make them as effective as possible, and at the same time cheap in construction. 2 claims.

5,368. "Improvements in telephony and in apparatus therefor." M. G. KELLOGG. Dated April 8. 11d. Relates to a metallic circuit multiple switchboard telephone exchange system, in which each line has a cord and a plug attached to it, to which the line is normally connected. The said plug rests normally in a switching device, and when it is desired to connect the line with another line for conversation the plug is removed from its normal position and placed in the switch of the line wanted. The invention includes a system of testing and apparatus, circuits, and connections for each line, whereby the operator may quickly and with few motions connect her telephone to the circuit of the calling line, may ascertain by a test whether the line wanted is already in use at another switchboard, may connect the two lines together, may send signalling currents over the lines, may receive a signal for disconnection, may connect her telephone into the circuit to determine whether the two subscribers have finished talking, and may disconnect the lines and place the line apparatus in readiness for receiving a new call. 13 claims.

5,369. "Improvements in telephony and in apparatus therefor." M. G. KELLOGG. Dated April 8th. 8d. Consists first in a system of testing the lines of the exchange by which they test "busy" whether they are switched at any board or their line annunciators indicate a call; and, secondly, to an organisation of apparatus for connecting two lines of ground circuit or one wire telephone exchange system by the use of one plug and cord, and for receiving the calls, answering the subscriber, calling, connecting with, and calling on the line wanted, receiving the disconnecting signals, and disconnecting the lines and placing them in condition to receive new calls and connections.

5,923. "An improved apparatus for use in distributing and regulating electric currents." C. W. SLEEMAN. Dated April 18th. 8d. The object of the invention is to provide an electrical instrument for the transmission of any portion of the whole amount of power or motion the particular instrument is capable of effecting. 4 claims.

5,925. "Improvements in telephony." M. G. KELLOGG. Dated April 18th. 11d. Consists first in a system and organisation of apparatus, circuits and connections for a multiple switchboard,

metallic circuit, single cord, telephone exchange system, whereby the operator at any board may expeditiously and with few motions connect her telephone to a line assigned to her to answer, when a call from the line is indicated, may test the line wanted to find whether it is already in use, may connect the two lines together and send a calling current which will ring the bell of the line wanted, may leave the lines connected together for conversation, may at any time connect his telephone to their circuit to determine whether they are through conversation, may receive on the calling annunciator of the line in which the call originated a signal to disconnect the connection and may disconnect the two lines and leave their apparatus in condition to receive or make new calls. Said system and organisation is, I believe, more simple, and the operations required are less than in other systems. Consists, secondly, in a system of testing such lines by which the lines test "busy," or in use, whether they are switched at any board or their line annunciators indicate a call. 14 claims.

6,945. "An improved electric switch." J. APPLETON. Dated May 5th. 8d. Relates to an arrangement by which the inventor is enabled to obviate, on the one hand, the imperfect breaking of the circuit when a spring becomes weak or is broken, and on the other hand large surfaces of contact between the terminals and the switch contact maker are secured without such accurate fitting as is required in switches of the ordinary construction. 1 claim.

7,599. "Improvements in electric arc lamps." R. BELFIELD. (Communicated from abroad by P. Lange, of America.) Dated May 15th. 8d. Relates to the construction of an electric arc lamp, more especially adapted for alternating electric currents producing an arc between the edges of two carbon slabs and travelling along those edges. 2 claims.

CORRESPONDENCE.

The Edison Dynamo.

We have read with interest the article in the ELECTRICAL REVIEW of Aug. 21st, concerning the small Edison dynamo, but fail to find anything very wonderful about it. Really, these "Americans" are a wonderful race of people. Here they are, boasting of a remarkable small dynamo. We, however, see nothing very remarkable about it, with the exception of its being a very badly proportioned, poorly designed, inefficient machine, running at a high rate of speed for a machine of its size.

Assuming the gauge of wire given in this article is B.W.G. We would draw your attention to the following comparison of this dynamo with one of our No. 4 "Infant" dynamos which will show, that although they may turn out a good and efficient large-size dynamo, they are somewhat at sea with regard to small machines.

	Revs. per min.	Ampères ab- sorbed in field magnets.	Output in ampères.
"Edison" dynamo	2,730	1.2 (approx.)	5 (approx.)
"Infant" "	2,000	1.1	12

It will be seen that for the same amount of energy absorbed in field magnets, our machine will give nearly three times the output.

We shall be pleased to furnish proof of our statement regarding our machine.

The weight of wire on our field magnets is the same as Edison's machine. We have, however, only two-thirds the weight of wire on the armature.

Austin & Myers.

August 24th, 1891.

We note that this wonderful machine is well protected by patents.

Aluminium.

In your leading article on aluminium in the current number of your paper, you state that "a bar of aluminium, 1 inch square, placed upon supports with 4 feet 6 inches space between them, deflects 2 inches with a load of 250 lbs., while a similar bar of cast iron requires double the load to give an equal deflection." I do not doubt the truth of this statement, but it is very incomplete, and, to be of real value, should be supplemented by information on the following points:—(1) The respective weight of both bars; (2) The weight required to break both bars; (3) and some information, at least, upon the ease or difficulty of straightening the bars, and their value when straightened.

August 24th, 1891.

O. Firth.

The St. Pancras Electrical Exhibition.

If you will kindly publish this letter in your next issue we shall be greatly obliged, for although the matter is neither edifying nor important, yet, since circulars containing an inaccurate statement concerning us have been printed and distributed, we feel bound to take some notice.

We, in common, we presume with the rest of exhibitors at the recent St. Pancras Electrical Exhibition, have received from Mr. Eccleston Gibb, the treasurer, a balance sheet accompanied by a circular concluding thus: "If Messrs. Potter and Joel pay the balance still due from them, viz. £4 10s. 10d., this will be distributed at a future date."

The facts are as follows:—We refused to pay our account in full, pointing out that, owing to the telephone exhibit having been placed in the small ante-room which formed the sole means of access to and egress from our stand, for the first week of the exhibition (especially during the evenings) visitors were quite unable to reach our exhibit, the throng in the telephone room being so dense.

Any of the exhibitors will corroborate this, and it was fully recognised at the time by the committee, the telephones being ultimately removed to a corridor on the ground floor.

Needless to say the success of our exhibit was seriously marred by this blunder on the part of those responsible for the arrangements.

On June 5th last we wrote to Mr. Eccleston Gibb regretting that a question had arisen with reference to our account, and enclosing cheque in settlement, which cheque was accepted, and until the receipt of the circular in question we were under the impression that the matter was settled.

We think that the publication of such a statement as that complained of shows very questionable taste on the part of Mr. Gibb, or whoever may be responsible, and in conclusion, we beg to state that we do not for a moment admit that any balance is due from us, nor have we any intention of making any further payment.

Henry F. Joel & Co.

August 26th, 1891.

Subsidy by Specification.

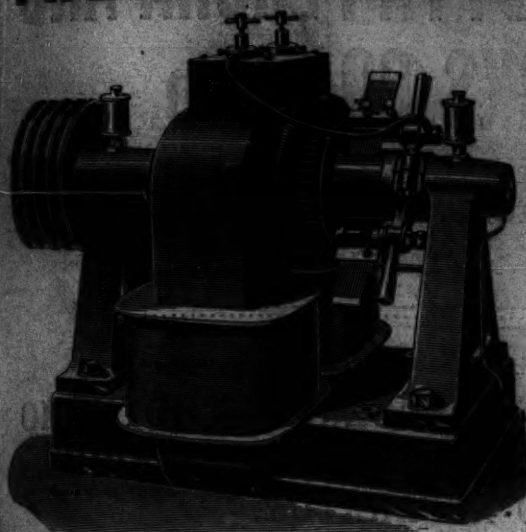
We have read the letter which appeared in your issue of the 14th inst. from the General Electric Company, Limited, and we hope that they alone of your readers are of opinion that our letter in the previous issue would be considered as reflecting upon the integrity of consulting engineers, inspectors of fire insurance companies, and others issuing specifications. We did not intend the word "subsidy" to convey that impression, nor do we think it should do so. We would also correct the impression that when we wrote the letter which appeared in your journal of the 7th inst., we had in our mind any one particular manufacturer. As a matter of fact, we had at that time two specifications before us, in one of which the Silvertown company's wires were specified, and in the other those of Messrs. Glover & Co. We differ entirely from the General Electric Company as to the utility of what they call the "antiquated form" introduced by telegraph engineers, by which the insulation resistance is specified as a means of ascertaining the quality of an insulating material.

We believe that no better form of testing can be devised than this test of insulation resistance, which indicates not only the quality of the rubber, but also the degree of skill employed in the manufacture. We believe the best standard that could be employed, at any rate for vulcanised India-rubber cables, which are so largely used in this country, would be that "antiquated form" which has been hitherto so successfully used by telegraph engineers, by which not only is the insulation resistance specified, but also the diameter of the cable outside the India-rubber. Modern electrical engineers must be aware of the advantage of the custom of buying gutta-percha wires insulated to a certain gauge, and it appears to us that there would be the same advantage if a similar form were adopted for electric light cables, as the insulation resistance would show that the quality of the material was right, and the diameter that the quantity was right.

W. T. Henley's Telegraph Works, Limited.
G. SUTTON, Manager and Secretary.

August 26th, 1891.

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1S	600	30 to 60	10	1,800	1	20	1 10	2 0
2S	900	40 to 70	15	1,750	1 1/2	24	2 0	2 10
3S	1,200	50 to 80	20	1,700	2	28	2 10	3 0
4S	2,100	50 to 110	35	1,600	3 1/2	38	3 0	3 10
5S	3,000	60 to 110	50	1,520	5	44	3 5	4 0
6S	4,500	60 to 110	75	1,430	7 1/2	55	3 15	4 10
7S	6,000	60 to 120	100	1,360	10	65	4 5	5 0
8S	9,000	60 to 120	150	1,280	15	85	5 0	5 10
9S	12,000	60 to 120	200	1,180	20	105	6 0	6 0
10S	18,000	80 to 150	300	1,020	30	146	8 0	—
11S	24,000	80 to 180	400	900	40	186	10 0	—
12S	30,000	100 to 200	500	800	50	225	12 0	—

These prices refer to Compound, Series or Shunt Machines wound to a difference of potentials between the limits given. For those of higher or lower potentials, an additional charge will be made and special quotations submitted.

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Size.	OUTPUT IN WATTS.	Difference of Potentials in Volts.	No. of 60 Watt Lamps.	Approx. Speed.	Approx. Horse Power.	PRICE.	Extra for Bedding Rails.
6D	9,000	65 to 110	150	750	15	110	6 0
7D	12,000	65 to 110	200	700	20	130	7 0
8D	18,000	65 to 110	300	650	30	170	8 0
9D	24,000	65 to 110	400	600	40	220	10 0
10D	36,000	110 to 125	600	500	60	290	13 0
11D	48,000	110 to 125	800	450	80	375	14 0
12D	60,000	110 to 125	1,000	400	100	450	16 0

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